A

NEW MATHEMATICAL DICTIONARY:

Wherein is contain'd, not only the

EXPLANATION

OF THE

BARE TERMS,

But likewiſe an

HISTORY

OF THE

Riſe, Progreſs, State, Properties, &c.

OF

THINGS,

Both in

Pure Mathematics,

And

Natural Philosophy,

So far as theſe laſt come under a Mathematical Conſideration.

The Second Edition, with Large Additions.

By E. STONE, *F. R. S.*

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Καθαρμοὶ ψυχῆς λογικῆς εἰσιν αἱ μαθηματικαὶ ἐπιστῆμαι.
Matheſis mentis expurgatio. Hierocl.

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M. DCC. XLIII.

TO THE

READER.

THE *first Impression of my Mathematical Dictionary being long since sold off, and the Booksellers having been from time to time frequently applied to, for the same, and that to no purpose; and considering the Usefulness of such a Work, not only to those, who may be somewhat stopt in their Reading of Authors for want of being acquainted with the Significations of some Words they may possibly meet with in these Arts and Sciences, or delight in the Historical Knowledge of Mathematicks, or else want a Guide to direct them to such as treat upon these Subjects: But likewise to those who are learned herein, by furnishing them with a convenient and necessary Repository of Rules, Propositions, and Properties, of the most notable and eminent Terms defin'd, to which they may have immediate Recourse, as often as occasion offers, either through Forgetfulness, or Want of Books ready at hand: These Inducements set me upon publishing this second Impression, with Corrections, Alterations, considerable Improvements, and Additions; the whole either itself sufficiently answering the Reader's present Expectations and Purposes, or at least pointing out such Authors as will. Particularly amongst the many Words herein ranged and*

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orderly explained, are to be found the following select ones, and their relative Appendages, viz.

Accessible Altitude, *How to measure the same, and how to measure the inaccessible Depth of a Well.*—Addition Algebraical, *How to perform it.*—Addition of whole Numbers, *How to perform and prove it.*—Addition of vulgar and decimal Fractions, *How to perform it.*——Æolipile, *Its Use, and some Authors that mention it, with an extraordinary Accident that happened upon setting one of them upon too great a Fire.*——Æther, *Sir* Isaac Newton's *Queries, relating to the Effects thereof,* &c.——Age of the Moon, *How to find it.*----Air, *Its Gravity, Density, Elasticity, Expansion, Height,* &c.—Air-Pump.——Adjutage, *The Laws of the Motion of Water through them.*——Alternations of Quantities, *The Rules to find them.*—— Altitude Inaccessible, *The best and most usual Ways of measuring such.*——Altitude of the Cone of the Earth's Shadow.——Amplitude, *How to find that of the Sun or Stars.*——Analemma, *Its first Inventor, and some Writers concerning it.*—— Angle of Contact, *Some Properties thereof.*—— Angle refracted, *How to find the Law of Refraction out of Air into Glass.*—— Apparent Diameter *and* Magnitude, *How to find them.*——Annuities, *Theorems relating to the same.*——Astrolabe.——Astronomy, *Its Antiquity, and some of the chief Writers concerning it.*—— Asymptotes, *Some Properties of them, and how to find them for geometrical Curves.*——Axis in Peritrochio, *The Proportion of the Power to the Weight raised by it.*——Azimuth Compass.

Back-Staff, *or* Sea-Quadrant.——Balance, *Its Properties.*——Barometer, *Rules to judge of the Weather by it.*——Binomial Theorem *of Sir* Isaac Newton, *its Use in the*

the Extraction of Binomial Roots, &c.—— Biquadratic Equation, *Its Formation, Reduction to a Cubic, Solution, and Construction.*——Biquadratic Parabola, *Several Species thereof, with some new Ovals expressed by its Equation.*—Bombs, *The first Use of them*, &c.——Burning-Glasses, *or* Speculums.

Calculus Differentialis, *or* Fluxions, *Sir* Isaac Newton's *own Account of his Invention thereof.*—— Catacaustic Curves.—Catenaria, *Its Nature and the Manner of finding Points thro' which it passes.*—Centre of Gravity, *How to find the same by Fluxions, and where that of several Magnitudes falls; also a Way how to find the Areas of Surfaces, and Solidity of Solids by means thereof.*—Centre of Oscillation *and* Percussion, *How to find it, and where that of some Magnitudes fall.*——Centripetal *and* Centrifugal Force, *Some Properties thereof, and some Writers upon the same.*—Characters, *The several Characters used in Algebra, Astronomy, and Music.*—Circle, *Many of the principal Properties of the Circle; amongst which are some rare and uncommon ones, with* Vieta's *very elegant Solutions of the Problems of Tactions*, viz. *the Description of a Circle to pass through one or more Points to touch one or more right Lines given in Position, and one or more Circles; also how to cut a given Circle into two Segments, that shall have a given Ratio.*—Cissoid, *Its Generation and Equation.*—Clock, *The first Inventor, and several Writers upon the same.*—Colours, *Some Account thereof from Sir* Isaac Newton.--- Combinations of Quantities, *The different Ways they may be varied.*---Comets, *Some Account of them, and Writers upon them.*--- Sea-Compass, *A Description, and the first Invention thereof.*--- Compound Interest, *How to find the same.*---Concave-Glass, *The*

The Quantity of the Diminution of an Object seen through one of them.---Conchoid, *Its Equation, and three Species thereof.*---Cone, *Its Generation, some Properties, and the Fluxion of the Surface of an oblique one.*--- Conic Sections, *Some Writings upon the same.*--- Construction of Equations, *How to perform the same by the Intersection of two Loci.*---Convex-Glass, *How to find its Focus, and the Magnitude of an Image seen through it.*--- Cubic Equation, *Some Properties of it, and how to extract the same, or find its Roots.*---Cubic Parabola, *Its Equation and Description, and some Properties of it.*--- Curves, *Some Writers concerning them.*——Cycloid, *Its Description, Equation and History.*--- Cylinder, *Some Properties of it.*

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tion. —— Erect declining Dials, *How to draw them.* —— Evolute Curves, *Their Descriptions, and some Properties of them.*——Exponential Curve.——Extermination, *of the unknown Quantity from an Equation, with Rules how to perform the same.*—— Extraction of Roots, *Some Rules to perform the same, and the Writers upon it.*

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Heat, *Some Properties thereof.*—— Helecoid Parabola, or Parabolic Spiral.— Heterogeneal Surds, *How to reduce them to one common radical Sign.* —— Homogeneal Surds.—— Horizon, *Its Uses.*—— Horizontal Dial,

How

How to describe the same.—— Hydraulics, *Some of the Writings thereon.*—— Hygroscope, *Its Description.*—— Hyperbola, *Various Ways of describing the same, and some of its general Properties.*

Imaginary Roots, *How to find them, according to Sir* Isaac Newton.—— Inclination of the Orbits of the Planets.—— Inclin'd Plane, *The Proportion of the Weight sustain'd by it, to the Power.*— Indetermin'd Problems, *Some Account of them, and the Way to resolve them.* — Index of a Quantity, *The Nature and Doctrine of Exponents.*——Inflection Point of a Curve, *How to find it in any Curve.*—— Ionic Order in Architecture, *The Proportions of its Pillar.*—— Isoperimetrical Figures, *Some Properties of them.*— Jupiter, *his periodic Time, Magnitude, comparative Distance from the Sun, and Earth,* &c.

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Magnet, or Load-stone, *Several Properties of its attractive Force or Virtue, and the first Invention of it.*—— Maps, *The first Inventors and Constructors from time to time afterwards.*—— Mars, *His Periodic Time, Magnitude, Comparation, Distance,* &c.——— Mathe-

matics,

matic, *A short History of it.*——Maximis & Minimis, *or* Methodus de Maximis & Minimis, *How to find the same.*—— Mean Motion, *Of the Sun and Moon.*—— Measure, *Useful Tables of different Measures.*—— Mechanics, *Several of the Writings thereon.*—— Mercator's Chart, *or* Projection, *Its Nature and Description, with the several Cases, and their Proportions, in* Mercator's *Sailing.*—— Mercury, *His Periodic Time, Comparative Magnitude and Distance,* &c. —— Meridian Line, *How to draw the same upon an Horizontal Plane.*—— Micrometer, *Some Writings thereon.*—— Microscope, *A short Account thereof.*—— Middle Latitude Sailing, *Its Use in Navigation.*—— Moon, *Her Periodic Time, and Distance from the Earth, Magnitude, Motion, Attraction,* &c.—— Motion, *Several Properties thereof.*—— Multiplication, *How to perform the same in Numbers and Fractions, Vulgar, Decimal, and Algebraical.*—— Musick, *A short Account thereof, with some Writings upon it.*——

Nocturnal, *The Description and Use thereof.*——

Opticks, *Some Writings concerning them.*—— Order of Curve Lines, *The general Properties of those of the second Kind.*—— Organical Description of Curve Lines, *How to describe those of the first Order, by a continued Motion, and by means of Points.*—— Orthographic Projection of the Sphere, *Its Laws.*—— Oscillation, *The Proportion of the Time of Performance of the same in the Archs of Cycloids and Circles, with the Length a Pendulum must have, that performs its small Vibrations in one Second of Time.*—— Oval, *How to describe what the Workmen call by this Name, and an Account of twelve remarkable Species of Ovals ex-*

 pressed,

pressed by the Equation $py^2 = -ax^4 + bx^3 + cx^2 + dx + e$.——

Parabola, *Its Generation, and some of its principal Properties.*——Parabolic Conoid, *Its Solidity and Surface.*—— Parabola Cartesian, *its most simple Equation, Description, and Use.*—— Parabola Diverging, *The several Species, most simple Equations, and Ways of finding Points, through which they must pass, and how the several Sections of a Solid, generated by the Rotation of a Semicubic Parabola, exhibits them all.*—— Parabolic Space, *A Hint at its Quadrature, from a Pyramid's being* $\frac{1}{3}$ *of a Parallelepipedon of the same Base, and Altitude,* &c.—— Parallel Ruler, *the Use thereof in reducing any Multangular Figure to a Triangle.*—— Parallelogram, *Some Properties thereof.*—— Pendulum, *the first Inventor, and the Use of them.*—— Perfect Numbers, *How to find them, by common Algebra.*—— Perpetual Motion, *the Impossibility of it.*—— Perspective, *Some Writers thereupon.*—— Plain Angle, *the several Equations for dividing it into two, three, four,* &c. *equal Parts.*—— Polar Dial, *its Nature, and some Theorems, by means of which it may be described.*—— Polygon, *Some Properties thereof, with a Table of Equations, for describing them in a Circle.*—— Polygonal Numbers, *The Rules for summing them up.*—— Position, *or* Rule of False, *How to perform the same.*—— Prism, *Some of its Properties.*—— Progression Geometrical, *Some of the Properties thereof.*—— Projectiles, *The Lines of Motion that they describe,* in Vacuo, *and Air.*—— Projection of the Sphere, *Some Writings concerning the same.*—— Projection Monstrous, *How to describe such.*—— Proportion, *The Nature, and some Properties of proportional Quantities,* &c.—— Protractor, *its Description and Use.*—— Ptolemaic System, *A short*

Account

Account thereof.—— Pully, *the Ratio of the Weight to be raised by it, to the Power raising it.*—— Pyramid, *Some Properties thereof, with an Algebraic Investigation of the Rules of finding the Solidity and Surface of a Frustum thereof, as also an easy Way of finding the Area of a Parabola, by the Method of Indivisibles.*——

Quadratic Equation, *The several Forms thereof.*—— Quadratrix, *Its Generation, and some Properties of it.*

Radius of the Curvature of a Curve, *The way of finding the same.*—— Rainbow, *Some Account, with an Explanation of the Cause thereof.*—— Ratio, *Some Account thereof, with the Investigation of the Rule of finding a Numerical Ratio in smaller Numbers, the nearest approaching a given Ratio in greater Numbers, whose Terms are Prime to each other.*——— Regular Polygon, *a Trigonometrical Examination of the Truth of the general Rule, which some have given to inscribe them in Circles.*— Resistance of a Medium, *The Proportions thereof to different Figures moving in it.*— Rhombs, *Some Propositions of Use in the Theory of Navigation, with their Demonstrations.*——— Right-angled Triangle, *How to find Series's of whole or mixed Numbers, accurately expressing the three Sides of a Right-angled Triangle.*— Rule of Three, *How to perform the same.*

Satellites of Saturn, and Jupiter, *Their Comparative Distances, Periodic Times,* &c.——— Sector, *A general Account thereof.* ——— Segment of a Circle, *An Approximating Rule to find the Area of it.*——— Segment of a Sphere, *How to find its Solidity.* ——— Semicubical Parabola, *Its most simple Equation.* ——— Series, *The Doctrine of Increments.*—— Solid of the least Resistance, *Its Nature.*—— Sound, *The Cause, and*

and some Properties thereof.——— Spheroid, *Its Solidity, and Surface with the Solidity of its second Segment, expressed in an Approximating Series.*—— Spiral Line of Archimedes, *Its Generation, and some Properties thereof.*——— Stentoreophonic Tube, *or* Speaking Trumpet, *The first Inventor, and those Writers who have mentioned the same.*——— Stereographic Projection of the Sphere, *Its general Properties.*—— Subtangent of a Curve, *A general Rule to determine it, in Geometrical Curves.*——Subtraction, *How to perform the same in whole Numbers and Fractions.* — Sun, *Several Particulars relating to its Comparative Magnitude, Density, Motion,* &c.— Surd Roots, *Some Account of them.*

Telescope Reflecting, *A short Description thereof: A very large one of Mr.* Jackson's *the Mathematical Instrument-Maker.*——— Tide, *Several Particulars relating to it.* ——— Trapezium, *Several Properties thereof, amongst which are five new ones, or at least, such as are not mentioned in any Writings which I have seen.*——— Triangle, *Many curious and useful Properties thereof, among which is* Honoratus Fabri's *Proposition about the three shortest Lines drawn from a Point within a Triangle to the three Angles, with a Geometrical Demonstration thereof.*— Trigonometry Plane, *The Canons, or Properties for the Solution of the several Cases thereof.*—— Trigonometry Spherical, *The several Affections of Spherical Triangles, with the Canons or Properties, by help of which all their Cases may be solved.*———

Venus, *Her Periodick Time, Comparative Distance, Diameter,* &c.

A

MATHEMATICAL DICTIONARY.

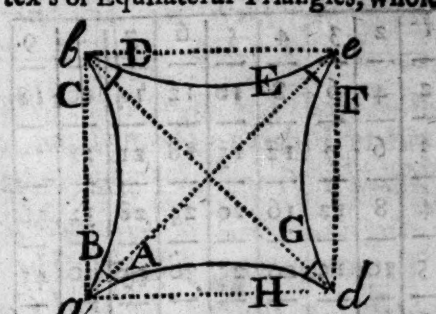
A

ABACUS, in Architecture, the upper Part or Member of the Capital of a Column.

In the *Tuscan*, *Dorick*, and *Ionick* Orders, it is most commonly square, (speaking in the Workman's Phrase) that is, every Section of it, parallel to the Horizon, is a Square. Some make it round, others make the Sides quite plain, without any Ogee, and some make it have a Fillet instead of an Ogee. The Height of it, in the *Tuscan* and *Dorick* Orders, is $\frac{1}{3}$ of that of the Capital; in the *Ionick* $\frac{1}{4}$ of that of the Capital.

In the *Corinthian* and *Composite* Orders, the Figure of the *Abacus* differs from that of the other Orders, the four Faces being circular, and hollow'd inwards, having a Rose on the Middle of each, and the four Corners cut off.

If the Square *a b c d* be equal to the Plinth of the Base, and four equal circular Arches, *ab*, *bc*, *cd*, *ad*, be drawn from Centres that are the Vertex's of Equilateral Triangles, whose



Sides are each equal to the Side of the Square; and if the Ends of the Arches be cut off by the equal Lines AB, CD, EF, GH, at right Angles to the Diagonals of the Square, each Line being $\frac{1}{10}$ of the Side of the Square, any Section of the *Abacus*, parallel to the Horizontal Plane of the Base, will be alike to the mixted Line Figure A B C D E F G H.

In the *Corinthian* Order, the

Height of the *Abacus* is generally $\frac{6}{49}$ of that of the whole Capital: *Vitruvius* makes it $\frac{1}{7}$; ſome make it leſs, others greater, as $\frac{1}{5}$ or $\frac{1}{6}$.

In the *Compoſite* Order, its Height is $2\frac{1}{4}$ of that of the lower Part of the Column.

Thoſe who have a mind to have a more particular Account of this Member, may conſult the Writings upon the five Orders of *Architecture*; amongſt which Mr. *Perrault*'s is a very good one.

Abacus, of *Pythagoras*, in Arithmetick, is the common Table of Multiplication, conſiſting of 81 Numbers, within a Square or Oblong, diſtributed into nine upright Columns, and nine Lateral or Horizontal ones; the nine Digits 1, 2, 3, &c. orderly proceeding in the firſt Horizontal Column, and the firſt upright one; the Numbers in each of the Horizontal Columns in order being the Products of the Multiplication of each Digit of the upper Horizontal Column, firſt by 2, then by 3, and ſo on till the laſt is multiplied by 9.

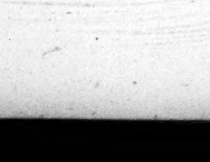
1	2	3	4	5	6	7	8	9
2	4	6	8	10	12	14	16	18
3	6	9	12	15	18	21	24	27
4	8	12	16	20	24	28	32	36
5	10	15	20	25	30	35	40	45
6	12	18	24	30	36	42	48	54
7	14	21	28	35	42	49	56	63
8	16	24	32	40	48	56	64	72
9	18	27	36	45	54	63	72	81

The Uſe of this Table is to ſhew by Inſpection, the Product of the Multiplication of any of the nine Digits; and thereby to aſſiſt thoſe who are about to learn Multiplication, to fix theſe Products in their Memory. The thing is done by ſeeking one of the Digits at the Head, and the other in the firſt upright Column; then the Number under that Digit at the Head, falling in the ſame Horizontal Row as that other Number is in, will be the Product of the Multiplication of thoſe two Digits.

In ſome Books of Arithmetick, I have ſeen a Table of Multiplication a good deal more compendious than this of *Pythagoras*, having no Number above a Digit twice, wherein one of the Rows of the Digits runs diagonally. The Table is this which is here annex'd.

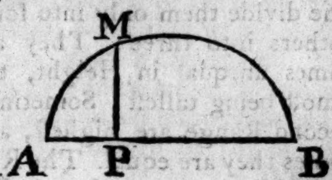
1	2							
2	4	3						
3	6	9	4					
4	8	12	16	5				
5	10	15	20	25	6			
6	12	18	24	30	36	7		
7	14	21	28	35	42	49	8	
8	16	24	32	40	48	56	64	9
9	18	27	36	45	54	63	72	81

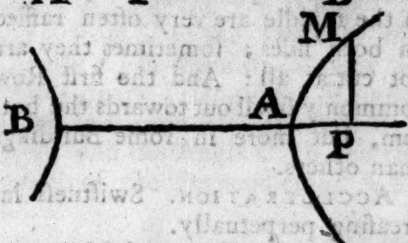
Absciss, ſtrictly ſpeaking, is a Part A P of the Diameter of a Curve Line, intercepted between the Vertex A of that Diameter, and the



Point

Point P, where any Ordinate or Semi-Ordinate M P to that Diameter falls.





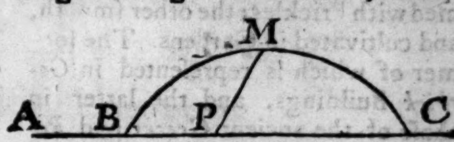
1. Hence there are an infinite Number of variable *Abſciſſes* in the ſame Curve, as well as an infinite Number of Ordinates.

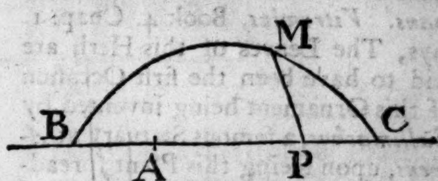
2. If the Curve be the common Parabola, one Ordinate P M has but one *Abſciſs* A P; if an Ellipſis, it has two *Abſciſſes*, A P, P B, falling contrary ways. And if an *Hyperbola*, conſiſting of two parts or Curves, one Ordinate PM has alſo two *Abſciſſes* A P, B P, both falling the ſame way.

3. If a Curve be one of the ſecond kind, one Ordinate may have three *Abſciſſes:* If the Curve be one of the third kind, one Ordinate may have four *Abſciſſes*, and ſo on; the greateſt Number of *Abſciſſes* being always one more than the Order of the Curve.

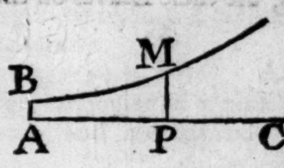
4. For Method's ſake, an *Abſciſs* in a Curve is uſually mark'd with the Capital Letters A and P, B and P, C and P, *&c.* the Point P being where the Ordinate falls, or elſe with the ſmall Letters, x or z.

5. As this Name was invented for more eaſily ſpeaking and conveying an Idea of the Nature of a Curve, by the Relation of an *Abſciſs* to its correſpondent Ordinate; or ſhewing Properties of them in ſuch and ſuch Curves; except this Word be taken in a larger Senſe, or ſome other Word be uſed, we ſhall be at a loſs to expreſs compendiouſly the Nature of ſuch Curves which have no Diameter, or even of thoſe that have, when we would mention their Nature by the Relation of Lines drawn parallel from Points of the Curve (*viz.* Ordinates) to Points of a ſtreight Line given in Poſition, within or without, or partly within or partly without, to the Part or Parts of this Line, intercepted between a given Point in it, and the Points where the ſaid Parallels do cut it. Therefore, in my Opinion, it may not be amiſs to define an *Abſciſs* more general, in ſaying it is the Part A P of a right Line given in Poſition, taken





from a given Point A in that Line to the Point P, where a right Line P M drawn from any Point M in a Curve Line B M C, in a given Angle M P C, cuts it.



6. In Mechanical Curves there are no *Abſciſſes*, properly ſpeaking, unleſs you will have Curv'd-lined ones; to be ſuch as in the common Cycloid are the Arches of the generating Circle taken from the Vertex of the Figure, when the generating Circle is in ſuch

a Situation, as to have the *Abscis* coincide with the Diameter.

Absolute, that which is independent upon, or has no relation to any thing else.

Absolute *Equation*, *Number*, *Motion*, *Quantity*, *Space*, and *Time*. See respectively *Equation*, *Number*, *Motion*, *Quantity*, *Space*, and *Time*.

Abstract *Mathematicks*, *Number*, and *Quantity*. See respectively *Mathematicks*, *Number*, and *Quantity*.

Abundant *Number*, See *Number*.

Acanthus. The Herb Bear's-foot, whose Leaves are represented in the Capital of the *Corinthian* Order of *Architecture*. There are two sorts of them; the one wild, and armed with Prickles; the other smooth, and cultivated in Gardens. The former of which is represented in *Gothick* Buildings, and the latter in those of the ancient *Greeks* and *Romans*. *Vitruvius*, Book 4. Chap. 1. says, The Leaves of this Herb are said to have been the first Occasion of this Ornament being invented by *Callimachus*, a famous Statuary at *Athens*, upon seeing this Plant spreading itself around a Basket that had been placed upon the Tomb of a young *Corinthian* Lady, and cover'd up with a Tile.

Vitruvius, *Serlio*, *Barbaro*, and *Cataneo*, use these Leaves on the Capitals of this Order. But most commonly in the antique Buildings, they are Olive Leaves raffled into five.

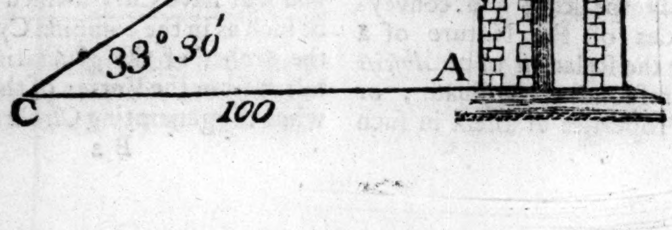
Some divide them only into four, and others into three: They are sometimes unequal in Height, the undermost being tallest: Sometimes the second Range are highest, and sometimes they are equal. The Ribs in the middle are very often raffled on both sides; sometimes they are not cut at all: And the first Row commonly swell out towards the bottom, but more in some Buildings than others.

Acceleration. Swiftness increasing perpetually.

Acceleration of *Motion* or *Velocity*. The same with accelerated Motion, or Velocity; which see.

Accessible *Altitude*, or *Height*, in Practical Geometry, signifies the Altitude or Height of any Object; as of a Tower, Steeple, Tree, &c. which may be either mechanically measured, by applying a Measure to it, or else, whose Base or Foot may be approached to, from a remote Station (usually on the Ground) without any Obstacle in the Way; as a River, Wood, House, &c. to hinder the speedy Mensuration from this Station to the Foot of the Altitude.

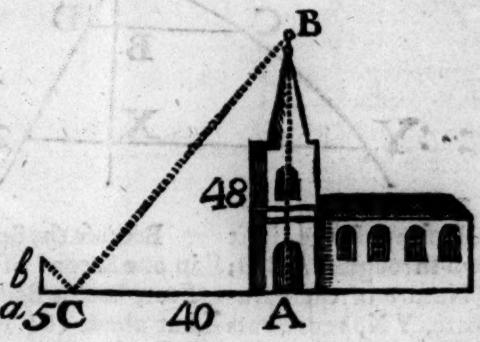
1. The most usual way of measuring an accessible Altitude or Height, AB, when its Base or Foot A can be



only

only approached, is by meaſuring the Diſtance from ſome Station C, on the Ground to the Foot A of the Altitude; and then at the Station C, taking, with a Quadrant, or ſome ſuch like Inſtrument, the Number of Degrees and Minutes contained in the angle C, formed by the Horizontal Line C A, and the Viſual Ray C B, going from C to the Top B of the Altitude: For when this is done, in the imaginary Triangle A C B, right-angled at A, you have the Baſe C A given, and the Angle C, to find the Length of the Perpendicular A B; which may be either performed by Scale and Compaſs, or arithmetically, by ſaying, as the Coſine of C: Sine of C:: A C: A B.

2. Another way of doing this, is, by placing a Bowl or Pail of Water, or a Looking-glaſs horizontally, at ſome convenient meaſured Diſtance C from the Foot A of the Altitude, and moving backwards or forwards, till the Top B of the Altitude is perceived by Reflexion in the middle of the Surface of the Water or Looking-glaſs. Then if *a* be the Place of Station when this happens, and the



Diſtance from *a* to C, as alſo the Height *a b* of the Eye be given, and you ſay as *a* C (=5 Feet): C A (=40 Feet) :: *a b* (=6 Feet): B A (=48 Feet); this will be the Meaſure of the Altitude A B.

The Reaſon of this follows from the Similarity of the right-angled Triangles *a b* C, A B C; which are ſuch from the Equality of the Angles *b* C *a* of Inſidence and Reflexion A C B.

Note, The Height of the Eye above the Place whereon you ſtand, muſt be added to the Perpendicular found, in order to have the true Height above the horizontal Plane.

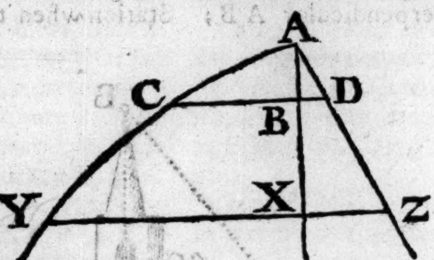
Thoſe who have a mind to be more fully informed how to find an acceſſible Altitude, will have plenty of Inſtances in Treatiſes of Practical Geometry, under the Title of *Altimetry*. The good old *Clavius*, in his *Practical Geometry, Lib.* 3. *Prob.* 39. publiſhed in the Year 1606, was the firſt who ſhewed how to find an acceſſible Altitude by means of a reflecting Surface, in the manner as delivered above.

Accessible *Depth*. A Depth the Perpendicular of which may be come at, and mechanically meaſured.

Sir *Iſaac Newton*, in his *Univerſal Arithmetick*, propoſes a very ingenious Way of meaſuring the Depth of a Well, from the Sound of a Stone ſtriking againſt the Bottom of it, and meaſuring the Time elapſed from the Moment the Stone is let fall until its

Sound be heard: For if t be that Time, a a given Space that a Body freely descending falls from the Beginning of its Motion, and b the Time in which it falls: Also, if d be the Time in which the Sound moves that given Space: then the Depth of the Well will be $= \frac{adt + \frac{1}{2}abb}{dd} - \frac{ab}{2dd}\sqrt{bb+4dt}$

Which Equation is gained from these two Theorems, *viz.* the Spaces described by the Fall of Bodies are to one another, as the Squares of the Times of Descent; and the Spaces described by Sound are as the Times. This Depth may be more easily computed, after the Manner of the excellent *Hugh de Merick*, in his *Analysis Geometrica*, than after Sir *Isaac*'s Method; as you may thus see. Let AX be the Depth, let AB be $= a$, BC $= b$, and BD $= d$; and conceive ACY to be part of a Parabola described through the Vertex A, and



the Point C: Also suppose the right Line ADZ drawn through A and D; then, from the Nature of the Parabola, any Ordinate, YX, represents the Time of the Fall from A to X; and if AD be continued down to Z, XZ will represent the correspondent Time in which the Sound moves that Space: Therefore YZ, the Sum of the Times, will be $= t$, *viz.* given. Make L : BC :: BC : AB. Then $L \times AX = \overline{XY}^2$. Wherefore L : XY :: XY : AX. Also DB : AB :: XZ : AX. Make L : M :: DB : AB. Then L : M :: XZ : AX, and L : XY :: XY : AX. Therefore $L \times AX = M \times XZ = \overline{XY}^2$; consequently M : XY :: XY : YZ — XY; that is (calling XY, z) M : z :: z : $t - z$. Therefore

$z = \sqrt{M \times t + \frac{1}{4}MM} - \frac{1}{2}M = XY$, and when you have this, it is easy to get AX, since $\frac{\overline{YX}^2}{L}$ is $= AX$.

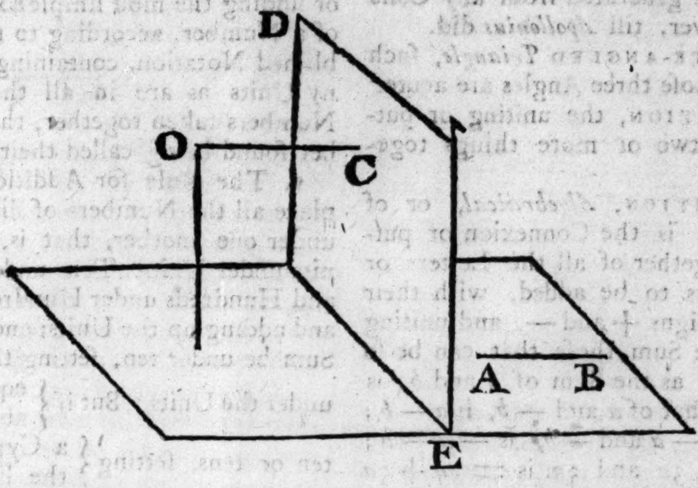
Because the Space moved by Sound in one Second of Time is about 1140 Feet, and a Body falls in that Time but about $16\frac{1}{2}$ Feet; the Quantity BD (d) will be very small in regard to CB, b. And so in finding the Depth of a Well, both BD d, and XZ, may be rejected without any great Error; and the Depth will be had, by making AX : AB (a) :: $\overline{YX}^2$ (t^2) : $\overline{CB}^2$ (b^2).

In the Supplement of the *Acta Eruditorum* for the Year 1713, pag. 317, and 339, an anonymous Author has largely explained and commented upon this ingenious Problem.

Achronical, a Word of very little use now-a-days; in vogue amongst the ancient Poets, regarding the Time of the rising and setting of the Stars with respect to those of the Sun: As a Star is said to rise or set *achronically*, when it rises or sets, when the Sun sets. But *Ptolemy*, *Kepler*, and other Astronomers, will have it, that a Star or Planet is said to

to be *achronical* when it is opposite to the Sun, and shines all Night. And so a Star or Planet is said to rise *achronically*, when it rises when the Sun sets; and sets *achronically*, when it sets while the Sun is rising.

ACCIDENTAL *Point* in Perspective, is that Point C wherein a right Line OC, drawn from the Eye O, parallel to one (Line AB) or more given parallel right Lines, meets the perspective Plane DE.



1. The Representations of all parallel Lines will, if continued, all meet upon the perspective Plane, in the *accidental* Point; and all Parallels to the geometrical Plane, when not so to the perspective Plane, have their *accidental* Point in the horizontal Plane. The manner of finding this Point is shewn in most Books of Perspective.

ACCORD, a Term in Musick, to be found in *Ozanam*'s *Mathematical Dictionary*, signifying either a Concord or a Discord.

ACHERNER, a Star of the first Magnitude in the Constellation *Eridanus*, whose Longitude is 10°. 31′. of *Pisces*, and Latitude 59°. 18′.

ACRE, a superficial Measure for Land, containing 160 square Perches: So that the Side of a square Acre will be nearly equal to 12.4691 Perches.

One would imagine, from the Ordinance for measuring of Land, made *anno* 33 and 34 of *Edward* I. and *Anno Dom.* 1306. wherein it is determined how many Perches in Length and Breadth shall make an Acre, that they had in those Days very indifferent Geometricians; when it is there said, That when an Acre of Land contains 10 Perches in Length, it shall contain 16 in Breadth; when 11 in Length, its Breadth shall be 14 Perches one half, and $\frac{3}{4}$ of a Foot; when 12 in Length, its Breadth shall be 13 Perches $5\frac{1}{2}$ Feet, &c. and so on to a Length of 40 Perches, and the respective Breadths. For all these Lengths and Breadths, except the first, might have been very well omitted.

ACUBENE, a Name given by some to a Star on the Southern Claw of *Cancer*.

ACUTE-*Angle*. See *Angle*.

ACUTE-ANGLED CONE, is such a right Cone, whose Axis makes an acute Angle with its Side. *Pappus*, in his *Mathematical Collections*, says, this Name was given to such a Cone

Cone by *Euclid*, and the Ancients before *Apollonius*'s Time; and they called an

ACUTE-ANGLED *Section* of a Cone, an Ellipsis, made by a Plane's cutting an acute-angled Cone; they not knowing that such a Section could be generated from any Cone whatsoever, till *Apollonius* did.

ACUTE-ANGLED *Triangle*, such a one whose three Angles are acute.

ADDITION, the uniting or putting of two or more things together.

ADDITION, *Algebraical*, or of *Algebra*, is the Connexion or putting together of all the Letters or Numbers to be added, with their proper Signs $+$ and $-$, and uniting into one Sum those that can be so united; as the Sum of a and b, is $a+b$; that of a and $-b$, is $a-b$; that of $-a$ and $-b$, is $-a-b$; that of $3a$ and $5a$ is $=3a+5a=8a$; that of $6a$ and $-2a=6a-2a$ is $=4a$; that of $a, b, c, -d$, is $a+b+c-d$; and so of others. The Order in which they are set down being of no great consequence, though it may not be amiss to set them down according to the Order of the Letters, writing a before b, b before c; and so on.

1. When a negative Number or Quantity is to be added to an affirmative one, the Sum is the Difference remaining, by taking away the negative Number or Quantity from the affirmative one; as 1 and -1 is 0; 4 and -3 is 1; $7ac$ and $-3ac$ is $4ac$; and so of others. But when the negative Number or Quantity is greater than the affirmative one, the Sum will be equal to what remains, by taking away the affirmative Number or Quantity from the negative one: But will be negative; as the Sum of -2 and $+1$ is $=-1$; of -10 and $+8$, will be -2; of $-\frac{5ac}{b}$ and $+\frac{5ac}{b}$, will be 0.

ADDITION of *whole Numbers*, or *Integers*, is an expeditious Way of finding one Number equal to two or more Numbers taken all together, or finding the most simple Expression of a Number, according to the established Notation, containing as many Units as are in all the given Numbers taken together, the Number found being called their *Sum*.

1. The Rule for Addition is to place all the Numbers of like kind under one another, that is, the Units under Units, Tens under Tens, and Hundreds under Hundreds, &c. and adding up the Units; and if their Sum be under ten, setting that Sum under the Units: But if $\left\{\begin{array}{l}\text{equal to}\\\text{above}\end{array}\right\}$ ten or tens, setting $\left\{\begin{array}{l}\text{a Cypher,}\\\text{the Excess,}\end{array}\right\}$ underneath, and for every ten, carrying a Unit to the next Place to the left hand, and so on; as if I should add

$$\begin{array}{rl} & 342 \\ \text{to} & 513 \end{array}\Big\} \text{ that is } \Big\{\begin{array}{l} 300+40+2 \\ 500+10+3 \end{array}$$
$$\text{Sum } 855 \quad = \quad 800+50+5.$$

2. The Demonstration of the Rule of Addition is very easy, and depends entirely upon the Notation in use, and *Euclid*'s *Axiom*, to wit, that the whole is equal to all the Parts taken together.

3. The addition of Numbers may be performed, by beginning to add up the first Column to the left hand, and then the other Columns in Order from the left to the right, according to the Rule above; and when all the Columns are gone through, their Sums will give the Sum of the Numbers to be added. And this may be a very good way of proving Addition.

96057

	96057	Example.
	9086	
	7025	
Sum	112168	
	9	
	22	
	0	
	15	
	18	
	112168	

This is observed (whether first I know not) by one *Desaguliers*, formerly a Professor of *Mathematicks* at *Amsterdam*, in a Treatise of his *de Scientia Numerorum*: As also by Dr. *Wallis* in his *Arithmetick*.

4. Addition may be proved several ways; first, by adding all the Numbers together, and afterwards distributing the Numbers into Parcels of 10 or 12 in a Parcel, (I speak of a great many Numbers to be added together;) and then adding together each Part by itself, and afterwards their Sums into one total Sum, and seeing whether the same total Sum comes to be the same in each way. Secondly, by casting away of 9's, (which I believe was first done by Dr. *Wallis* in his *Arithmetick*, published *anno* 1657) which is thus:

Take each of the given Numbers separately, and add all their Figures together as simple Units, and in doing so, when you have made a Sum equal to 9, or greater than 9, but less than 18, neglect the 9, taking what is over, and add to the next Figure; and go on so till you have gone through them all, and mark what is over or under 9 at the last Figure: But if the Sum of all the Figures be less than 9, set down that Sum. Do the same with each of the Numbers, setting all these Excesses of 9 together in a Column; then sum them up the same way, making the Excess of 9, as before, or what the Sum is less than 9. Lastly, Do the same with the total Sum, and what is under 9, or over any Number of 9's in this, must be equal to the Excess or Number less than 9, last marked; if not, your Work has been wrong. For example,

	Excess of 9.
2743	7
4678	7
5365	1
12786	6

Though this Proof of Addition be not quite to be relied upon, because a wrong Sum may sometimes appear true from it; yet the Probability of its being true, to that of its being false, is very great. And so we may be pretty secure of the Truth of any Sum proved this way.

Dr. *Wallis*, in the Treatise above mentioned, was the first who shewed this last way of proving Addition, with the Reason of the same. You will also find it in Mr. *Malcolm*'s *Arithmetick*.

Addition of *Fractions*, is finding a Fraction equal to two or more given Fractions.

This is done by reducing all the given Fractions (to simple Fractions of one Unit, if they be numerical Fractions) to one Denomination, if they be not so already: Then the Sum of the Numerators being made a Numerator to the common Denominator, makes the fractional Sum sought; which may be further reduced as the Case requires.

EXAMPLES.

$\frac{a}{b}+\frac{c}{b}$ is $=\frac{a+c}{b}$; alſo $\frac{ab}{c}+\frac{ad}{e}=\frac{abe}{ce}+\frac{acd}{ce}$ is $=\frac{abe+acd}{ce}$.

And $\frac{2}{7}+\frac{3}{7}$ is $=\frac{5}{7}$, and $\frac{2}{5}+\frac{3}{7}\ \left(=\frac{14}{35}+\frac{15}{35}\right)$ is $=\frac{29}{35}$, and

$\frac{3}{7}\,l+\frac{2}{7}\,sh.\ \left(=\frac{60}{7}\,sh.+\frac{2}{7}\,sh.=\frac{62}{7}\,sh.=8\frac{6}{7}\,sh.\right.$

Addition of *Decimal Fractions*, is finding a Decimal Fraction equal to two or more given Decimal Fractions.

The Rule to do it is; Whether the Numbers given be pure or mixed Decimals, or ſome of them whole Numbers, write them down under one another, in ſuch Order that the Decimal Points on the left ſtand all in a Line, or under one another; and the Figures all in diſtinct Columns, in order as they are removed from the Point either on the right or left: Then, beginning at the Column on the right hand, add the Figures in every Column together, as in whole Numbers, placing a Point in the Sum, under the Points of the given Numbers.

EXAMPLES.

.24	.004	36.24
.378	.015	450.058
.057	.3678	378.72
.9356	.291	42.005
.6827	.6778	
2.2933		

Addition of *Ratio's*, the ſame with ſome of the modern Writers, as Compoſition of *Ratio's*. Which ſee.

Aderaimin, or Alderamin, is a Star upon the left Shoulder of *Cepheus*.

Adhil, is a ſmall Star of the ſixth Magnitude, upon the Garment of *Andromeda*, under the laſt Star in her Foot.

Adjacent Angle. See *Angle*.

Æolipile, a round hollow Ball of Iron, Braſs, or Copper, having a Neck in which there is a very ſlender Pipe opening into the Ball; which, if ſcrewed on, is the beſt way, becauſe then the Cavity may be more eaſily filled with Water.

This Inſtrument, of more Curioſity than real Uſe, is for repreſenting a kind of artificial Wind; and that after the following manner:

Fill it almoſt full of Water, which you may eaſily do if the Neck unſcrews; if not, you may heat the Ball red-hot, and throw it into a Veſſel of Water, which will be ſucked in through the ſmall Hole, if it be kept immerged. This done, if the Æolipile be put upon, or before the Fire, ſo that the Water and it be very much heated, a vapourous Air will fly out through the Pipe, with great Noiſe and Violence; but by Fits, and not with a conſtant and uniform Blaſt.

This Inſtrument is ancient, being mentioned by *Vitruvius*, *Lib.* 1. *Cap.* 6. *Deſcartes* too ſpeaks of it in his *Meteor. Cap.* 4. It is alſo mentioned in ſeveral other Authors, amongſt whom Father *Merſennus*, *Prop.* 29. *Phænom. pneumat.* uſes it to weigh the Air, by firſt weighing the Inſtrument when red-hot, and having no Water in it; and afterwards weighing the ſame when it becomes cold. But the Concluſion gained from this Operation cannot be very accurate, ſince there is ſuppoſed to be no Air in the Ball when it is red-hot. *Varenius* alſo, in his *Geogr. cap.* 19. *Sect.* 6. *paragr.* 10. uſes it to ſhew the Air's Rarefaction by Fire.

There is one thing I would have obſerved

obſerved in the Uſe of this Inſtrument; and that is, that you take care it be not ſet upon too violent a Fire, with too little Water in it, for fear leſt it ſhould burſt and do miſchief; which may ſometimes be the Caſe, as once happened to my knowledge. A Perſon ſetting one of theſe Copper Inſtruments upon too great a Fire in a Tavern Drinking-room, it burſt with a Noiſe like a Cannon, into ſeveral pieces; which flew about the Room, and cauſed ſuch a violent Concuſſion of the Air, as not only put out the Candles upon a Table, and threw down the Bottles and Glaſſes, but broke moſt of the Panes of Glaſs, in Number 12 or 14, of a Sky-light, being the only Window in the Room.

ÆRA, the ſame as *Epocha*; which ſee.

ÆTHER, a very thin elaſtick and active Fluid, readily pervading the Pores of all Bodies, and by its elaſtick Force expanded thro' all the Heavens. Much rarer within the Pores of denſe Bodies, as thoſe of the Sun, Stars, Planets and Comets, than at Diſtances from them, growing denſer and denſer perpetually, as the Diſtance increaſes; cauſing the Gravity of thoſe Bodies towards one another, and of their Parts towards the Bodies; the Reflexion and Refraction of the Rays of Light; the Duration of the Heat of hot Bodies; the Communication of their Heat to cold Bodies; performing Viſion by its Vibrations, excited in the Bottom of the Eye by the Rays of Light, and propagated through the ſolid, pellucid and uniform *Capillamenta* of the Optick Nerves into the Place of Senſation; and animal Motion excited in the Brain by the Power of the Will, and propagated from thence through the ſolid pellucid *Capillamenta* of the Nerves into the Muſcles, for contracting and dilating them; and ſo exceedingly thin, as not to cauſe any ſenſible Reſiſtance in the Motions of the Planets in many thouſand Years.

All this is from Sir *Iſaac Newton*'s *Queries*, at the latter part of his *Opticks*. It is pity we have not Experiments ſufficient to ſhew there is ſuch a Fluid, and ſomewhat ſurpriſing this great Man himſelf, who was the moſt likely of any Mortal to diſcover any ſuch Fluid, ſhould make Queries about the Effects of it, before he was aſſured of its real Exiſtence; eſpecially if he had no other Proof than the Experiment we find at the latter end of the *Scholium*, at *Sect.* 6. *Lib.* 2. *Princip. Mathem. Philoſoph. Natur.* The Subſtance of which is, That he made a Pendulum of a deal Box, of about 11 Foot long; and having raiſed up the Box to a noted Place, ſix Foot from the Perpendicular, and then having let it go, he marked three other Places to which it returned, at the end of the firſt, ſecond and third Oſcillations. After which he filled the Box with Lead, and other heavy Metal, having firſt weighed the empty Box, the part of the Thread the Box was hung to, which was wrapt about it, one half the Thread, and as much Air as the Capacity of the Box took up; and the whole Weight was about $\frac{1}{78}$ part of the Box of Metal. Then having ſomewhat ſhortened the Thread, by reaſon of the Box of Metal's ſtretching it, ſo that the Pendulum had the ſame Length as at firſt; he drew up the Box to the Place firſt obſerved, and letting it fall, numbered about 77 Swings before the Box returned to the ſecond Place marked, and as many afterwards before it returned to the third Place, and ſo alſo before it returned to the fourth Place. From whence he concluded, that the whole Reſiſtance of the Box when full, to that when empty, had not a greater

greater Ratio than 78 to 77: For if the Reſiſtance of both of them were equal, the full Box, by reaſon of the inactive Force of its Matter, being 78 times greater than that of the empty Box, ought to have preſerved its ſwinging Motion ſo much the longer; and ſo it muſt have returned to the four marked Places always when 78 Swings had been performed: But it returned to the ſame when 77 Swings had been compleated. Therefore, ſays he, if A be the Reſiſtance of the external Surface of the Box, and B the Reſiſtance of the empty Box in the internal Parts; and if the Reſiſtances of equally ſwift Bodies in the internal Parts, be as the Matter or Number of Particles which is reſiſted, 78 B will be the Reſiſtance of the full Box in its internal Parts: And ſo the whole Reſiſtance A + B of the empty Box, will be to the whole Reſiſtance A + 77B of the full Box, as 77 to 78. And therefore A is to B as 5928 to 1; that is, the Reſiſtance of the empty Box in the internal Parts, is about five thouſand times leſs than its Reſiſtance in its external Superficies. And all this could not happen but from the Action of ſome ſubtle Fluid included within the Metal, or elſe by ſome other unknown Cauſe.

Africa, one of the four great Continents, or general Parts of the Earth, containing *Egypt*, *Barbary*, *Bildulgerid*, *Zaara*, *Negroe-Land*, *Guinea*, *Nubia*, and *Æthiopia*; and the moſt remarkable Iſlands thereof are the *Canaries*, *Maderas*, *Madagaſcar*, and *Cape Verde* Iſlands. It is bounded on the Eaſt with the *Red Sea* and *Arabia*, on the Weſt by the *Atlantick*, on the North by the *Mediterranean*, and on the South by the *Æthiopick* Oceans. It is joined to *Aſia* by an Iſthmus, of 40 *German* Miles broad, which ſome Kings of *Egypt*, and *Sultans*, had a Deſign, and attempted to cut thro', to open a Paſſage from the *Red Sea* to the *Mediterranean*, but in vain: And *Cleopatra* thought to have hoiſted her Fleet over it from the *Mediterranean* to the *Red Sea*, to get clear of the *Romans*. Between the Channel of the River *Nile*, and the *Red Sea*, that Iſthmus is but nine Miles. This Country is ſomewhat of a triangular Figure. The Baſe may be reckoned at *Tangier*, from whence to the *Iſthmus*, it is about 1920 Miles broad; but from the Vertex of the Triangle, to the northermoſt Part of the Baſe, 4155 Miles; being much leſs than *Aſia*, and about three times as big as *Europe*. A great part of it is ſituate under the *Torrid Zone*, and croſſed by the Equator. The furthermoſt ſouthern Bound being the Cape of *Good Hope*, in about 34 Deg. of South Latitude; and the moſt northern Extreme is about *Barbary*, in the Lat. of 37 Deg. North.

A great Part of this Country was unknown to the Ancients; and even now the Inland Parts thereof are not well diſcovered. The general Hiſtorians thereof are, *Leo*, *Marmol*, *Metellus*, *Gramaye*, M. *Livio Sanuto*, *Le Croix*, and *Dapper*; which laſt is reckoned the beſt extant, and abridged by Mr. *Ogilby* in an *Engliſh* Folio Edition. There are alſo many Travellers to particular Parts: as *Paul Lucas* up the *Nile*, as far as the *Cataracts*; *Don John de Caſtro*'s Voyage up the *Red-ſea* to *Sues*, in the Year 1540; and *Chardin*, *Le Brun*, and *Vanſleb* to *Egypt*. For the Deſarts of *Arabia* and *Meſopotomia*, we have *De la Valle*, *Teixira*, *Thevenot*, *Vertoman*, and Sir *Henry Middleton*. But in all theſe we have ſcarcely any Accounts of the Inland Parts of *Arabia Fœlix*; nor has any body deſcribed the Inland Parts of *Barbary*, *Zaara*, *Bildulgerid*, and the lower *Æthiopia*.

The

The Travellers to the upper *Æthiopia*, are *Bermuda*, *Almeida*, *Peter Pais*, *Ludolphus*, the *Jesuits* Letters, *Poncet*, *&c.* but the best Account of all is, the *Historia del Æthiopia per* Telles; being a Collection of all the Authors aforesaid, except one or two.

To *Morocco*, there are *Moquet*, *Movett*, *St. Olon*, *L'Estat de Royaumes de Barbary*, *Frejus* to *Mauritania*, *Janiquin* to *Libia*, &c. *Jobsen*'s Voyage to the River *Gambia*. *Bosman*'s Description of *Guinea*, is the best I am told for that Country, and likewise *Tenrhyne*'s for the *Cape of Good Hope*. There are many other Authors who have described particular Parts of *Africa*, which I cannot mention, because I have not seen them.

AFFIRMATIVE *Quantity*. See *Quantity*.

AFFIRMATIVE *Sign*, in *Algebra*, is this, +.

This Sign before and between two or more Numbers, or literal Expressions of them, or Quantities, implies their Sum, Addition, or putting together, being an elegant Mark to use instead of the Words *plus*, *more*, or *added to*, and of more Assistance to the Imagination; as + 5, + 7, or *plus* 5, *plus* 7, or *more* 5, *more* 7, or 5 *added to* 7, signifies the Sum of 5 and 7, *viz.* 12; so also + a, + b, or *plus* a, *plus* b, or *more* a, *more* b, or *added to* b, is the Sum of *a* and *b*. So also in Geometry, the Lines + AB + CD + EF, signifies the Sum or Aggregate of the Lines AB, CD, and EF; that is, these Lines put together.

AGE, *of the Moon*, is the Time elapsed, or the Number of Days (always less than 30) from any proposed mean Conjunction, or new Moon, to the next, and is to be had from most of our common Almanacks. But yet, without these, may be found,

1. By taking the mean Place of the Moon from that of the Sun at the given Time (a whole Circle being added when necessary) which Difference will be the Moon's mean Elongation from the Sun; and dividing this by the mean Diurnal Elongation, being the Difference between the Sun and Moon's Diurnal mean Motions; and the Quotient is the mean Age of the Moon, that is, the Time elapsed from the last new Moon.

2. Or more easy; by adding to the Radix of the mean new Moons (suppose that of the Year 1700, being 21*d.* 13*h.* 5*m.* 34*s.*) the Epacts of the given Years, Months, Days, Hours and Minutes; and from the Sum taking compleat synodical Months, one of which is 29*d.* 12*h.* 44*m.* 3*s.* and the Remainder will be the Moon's Age.

The Moon's Age may also be found, by turning the Difference between the Time given, and the known Time of any past Conjunction, or of an Eclipse of the Sun, into Days, Hours, *&c.* and afterwards multiplying the same by 10*d.* 15*h.* 11*m.* 38*s.* and then dividing the Product by 29*d.* 12*h.* 44*m.* 3*s.* and the Remainder, after the Division, will be the Moon's Age.

Note. At the End of every 19 Years, the Moon's Age will return upon the same Day of the Month, but will fall short of the precise Time by a small quantity.

I have seen in some Books of Navigation, under what is called the *Julian* Calendar, (such as *Atkinson*'s Epitome, *&c.*) a very easy way to find the Moon's Age: But it is not exact enough, and so shall say nothing of it.

AIR, or ATMOSPHERE, an invisible, compressible, dilatable, elastick fluid Body, in which we breathe and live, encompassing the whole Earth

Earth to a great Height, being hardly perceivable by our Senses; but that manifests itself by its Resistance to Bodies moved in it, and by its strong Motion against other Bodies, at which time it is called Wind, being absolutely necessary for the Vitality of Animals and Vegetables, the Collection, Preservation, Direction and Augmentation of Fire.

Some of the most noted Properties of the Air are as follow:

1. It contains various Kinds of Corpuscles swimming in it; neither can it be deprived of its Fluidity by the utmost Cold or Compression, nor made visible to the Eye by the best Microscopes; and all Bodies have more or less Air contained within them: And tho' the Particles of this Fluid are exceeding small, yet they cannot make their way through Metals, Glass, Wood, or good Paper, which even those of Wine, Water, &c. will do.

2. *Galileus*, in his Mechanical Dialogues, was the first who discovered that the Air was heavy; for, by thrusting it into a hollow Ball by means of a Syringe, he found the Weight of the Ball augmented; and, upon opening the Ball, found it to have the same Weight as at first.

Torricellius, the *Florentine* Geometrician, *Anno* 1643, first attempted to weigh the Air; and after him *Otto Guerick*, a *German*, and then *Burcher de Volder*, (*in Quæstionibus Academicis de Aëris gravitate*) who says, that the Weight of a Cubick Foot of Air is one Ounce and 27 Grains; and this by such nice Scales, that if 25 or 30 Pounds was put into each, a manifest Preponderation would ensue, upon putting in, or taking away one or two Grains from one side or other, Mr. *Boyle* says, about $\frac{2}{3}$ of a Pint of Air weighs one Grain and $\frac{1}{8}$ Part; and Mr. *S'Gravesande* found, that the Air in a Glass Ball of about 283 Inches Capacity, weighed 100 Grains. But it is found that no two equal Quantities taken at the same time, but at different Heights, were ever found of equal weight, the lower Air always outweighing the upper. Even in the same Place, an equal Quantity of Air will scarcely ever be found to be of the same Weight.

3. The common Air near the Surface of the Earth, as well as the Surface and all Bodies upon it, are continually pressed by the Weight of the Atmosphere, or of the upper Parts upon the lower; and this Weight is greatest, the nearer Bodies are to the Center of the Earth, and lesser the higher you go: which Weight, upon every square Inch near the Surface of the Earth, is about 15 Pounds *Avoirdupois*. Mr. *Boyle* says, he found it to be $18\frac{1}{2}$ Pounds *Troy*. But it may be observed, that the Weight of the Atmosphere in our Climate is constantly changing, which Change is observable upon the Alteration of Weather. And by repeated Experiments of about 86 Years, we come at length to know, that in *Europe* the greatest Weight of the Atmosphere is ballanced by a Column of Mercury of 31 Inches in Height, and the least by one of 28. Also the Atmosphere's Pressure upon the same Bodies in the same Places is variable, which Variation notwithstanding is never found in the same Place to exceed $\frac{1}{10}$ of the whole. Moreover, Air presses upon every Side of Bodies with an equal Force.

4. The Air has an elastick Property, that is, all known Air occupying any certain Space, and being confin'd there so that it cannot escape, will, when pressed by a determinate Weight, reduce itself into a less Space, which will be always reciprocally proportional to the com-

compressed Force, and the Density proportional to it; and when that Weight is removed, the Air will of itself be restored to the Space it had lost.

Mr. *Boyle* says, that two polish'd Marbles, which would in open Air sustain a weight of 80 Pounds, before they would fall asunder, would do so in the exhausted Receiver with a Pound, and sometimes half a Pound weight. And the same Philosopher says also, that the Weight of a Cylindrical Column of one Inch in Diameter, is 14 Pounds, 2 Ounces, and 3 Drams *Troy*. And Mr. *S'Gravesande* says, when the Air was drawn out of two equal Brass Hemispheres well joined together, of $3\frac{1}{2}$ Inches in Diameter, it would require a weight of 140 Pounds to pull them asunder.

5. Air may be condensed by Art, so as to take up but the 60th part of the Space it did before, as has been done by several, and which may be seen in the *Philosoph. Transact.* N° 182. It is very hard to reduce the common Air into a Space 64 times less than it naturally takes up; and since it is probable, that the $\frac{1}{1000}$ part of the common Air at least consists of aqueous, spirituous, oily, saline, and other Particles scattered thro' it, it is likely that common Air can never be reduced into a space 1000 times less than it usually takes up, without becoming solid.

6. The elastick Power of any Portion of Air, can by the Air's Expansion repel the Bodies that compress it, with the same Force as that which is exerted by the whole Body of the Air.

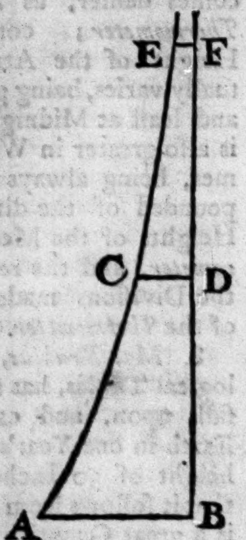
7. When Air is condensed in a certain determinate Degree by the Application of Heat, it acquires a greater Power of Expansion every way than it had before; that is, it is rarified, or becomes thinner: and on the contrary, by Cold it is contracted into a smaller Space, and becomes denser, as appears by the *Thermometer*; consequently the Height of the Atmosphere perpetually varies, being greatest at Noon, and least at Midnight. Its Density is also greater in Winter than Summer, being always in a Ratio compounded of the direct Ratio of the Heights of the Mercury in the *Barometer*, and the reciprocal Ratio of the Divisions made to the Degrees of the *Thermometer*.

8. Mr. *Krukius*, in his Meteorological Tables, has shewn, that there falls upon, and exhales from, the Earth in one Year's time, about the height of 30 Inches of Water; so that it follows from hence, that there is a great Quantity of Water always suspended in the Air, under the Form of Fog, Rain, Dew, Hoarfrost, Snow, *&c.*

9. If Altitudes of the Air be taken in the same arithmetical Progression increasing, the Densities thereof will be in a geometrical Progression decreasing. But this is on the Supposition that the Density of the Air condensed by Compression is as the compressive Force, or, which is the same thing, the Space taken up by the Air reciprocally as that Force. Dr. *Halley*, I believe, is the first who published a Demonstration of this in *Philos. Transact.* N° 181. by means of an asymptotical hyperbolical Space. Dr. *Gregory* too, in his *Astronom. Prop.* 3. *Lib.* 5. has shewn the Truth thereof by the Logarithmick Curve. Moreover, Dr. *Jurin*, in his *Append. ad Geogr. Varenii*, has compendiously demonstrated the same, by a Method not at all different from that of Sir *Isaac Newton*, in *Lib.* 2. *Princip. Mathem prop.* 2.

From this Theorem, it is easy to find the Density of the Air at any given

given Height above the Earth's Superficies; for let the right Line AB be 33 Feet, *viz.* the Altitude of a Column of Water of the same Weight with a Column of Air quite up to the Top of the Atmosphere; and let BDF be perpendicular to AB; assume BD equal to 850 Feet, being the Number of times that the weight of a Quantity of Water exceeds that of the same Quantity of Air: that is, a Column of Air 850 Feet high, of the same Weight with a Column of Water one Foot high. Then if DC be drawn perpendicular to BD, and made equal to 32 Feet, it will represent the Density of the Air at the Height of 850 Feet. This done, if a Logarithmic Curve ACE, be supposed to pass thro' the Points A, C; the right Line BDF will be its Asymptote, and any Ordinate EF will be as the Density of the Air at the correspondent Altitude BF: so that if the Density EF of the Air at a given Height BF be wanted, say as BD is to BF, so is the Difference between the Logarithms of AB and CD, to a fourth number, which will be the Difference of the Logarithms of AB and EF; and since the Logarithm of AB is given, you will have that of EF, and so EF itself. Sir *Isaac Newton*, towards the End of *Lib.* 3. *Princip. Mathem.* concludes from a Computation of this kind, that a Globe of our Air of the Diameter of one Inch, if rarefied so much as it must be at the Distance of the Earth's Semi-diameter from the Earth, will fill all the planetary Regions as far as, and much beyond, the Sphere of *Saturn*.



9. These Theorems are founded upon the Supposition, that the Air, as you go higher and higher, is of the same Nature with that near the Earth. But Experiments shew it to to be otherwise; for Mr. *Cassini*, and *Picart*, when measuring the Heights of several Mountains, diligently observed the several Altitudes of the Mercury of the Barometer, and by that means found, that the Proportion of the Rarity of the Air was not according to Dr. *Halley's* Theorem, but much greater than what ought to arise from the said Proportion. See *Hist. de l'Acad. Roy. Anno* 1703 & 1705. Moreover Dr. *Halley*, and the *Academy del Cimento*, assert, that the Reduction of Air into Spaces proportional to the compressive Weights, does not hold good beyond that Space, which is 850 times less than that which is taken up by the common Air.

10. It is likely that the Height of the Atmosphere is indefinitely extended many (perhaps thousand) Miles above the Surface of the Earth. Tho' several Authors will have it to be of a small limited Height: But about this Height they differ very much. *Possidonius* makes the Height $12\frac{1}{2}$ *German* Miles; *Alhazen* and *Vitellio*, 13; *Clavius* and *Nonius*, 11; *Tycho Brahe*, 12; *Gassendus*, 10; *Ricciolus*, $19\frac{1}{2}$ when lowest, and $16\frac{1}{2}$ when highest; *Varenius* makes it $\frac{1}{8}$ of a *German* Mile, from two observed Altitudes of a Star at two Altitudes, at *Prop.* 30. *Sect.* 6. *Cap.* 19. *Geogr.* and in *Prop.* 38. he makes it $1\frac{1}{2}$ *German* Mile. Mr. *Boyle* makes it 7 *English* Miles; but, upon a Supposition it is every where of the same Density. *Harris* and some others will

will have it to be about 41 *English* Miles. But all these, in my opinion, are little better than mere Suggestions, computed from uncertain, erroneous Principles, chiefly grounded upon the Observations of the Twilight, which is observed commonly to begin and end when the Sun is 18 Deg. below the Horizon; as appears from what *Varenius* says at *Prop.* 37, 38. *Sect.* 6. *Cap.* 19. of his *Geogr.*

11. The Pressure of the Air, near the Surface of the Earth, upon any Base, is ballanced by a Column of Water of the same Base, of about 33 Feet in Height when that Pressure is greatest, and of about 30 Feet when that Pressure is at a Mean. From whence, and by the Theorem at N. 8. it follows, that the Expansion of the Air will be 4096 times more than at the Surface of the Earth; and at that Height, the Altitude of the Mercury in the *Torricellian* Tube, will be but about one hundredth part of an Inch.

12. The first who observed the Ballance of the Air with Water, was a Gardener of *Florence*, who, wondering that he could not raise Water in a Pump, higher than to 18 Cubits, communicated the unexpected Phænomenon to *Gallileo*, who himself did not then know any thing of it; as you find in his *Mechanical Dialogues*, 1 *p. m.* 15, 16. first published about the Year 1638. After him several others experienced the same thing, amongst whom was Mr. *Marriotte*, a *Frenchman*, who found that Water would not rise higher than 32 *Paris* Feet. And *Torricellius*, a Scholar of *Gallileo*, using Mercury instead of Water, found it would be suspended at about 30 Inches.

13. The Weight of any Quantity of Air, to the same Quantity of Water, near the Earth's Surface, acording to *Mersennus*, is as 1 to 1356; according to Mr. *Boyle*, as 1 to 1000; according to Dr. *Halley*, in the *Philosoph. Transf.* N. 181. as 1 to 800; according to Mr. *Haukshee*, in the said *Transf.* N. 305, as 1 to 885, (which is esteemed the nearest to the Truth).

14. Sir *Isaac Newton* (in *Schol. sub fin. Sect.* 9. *lib.* 2. *Princip.*) says, If the Particles of the Air be supposed nearly of the same Density with Particles of Water or Salt, and the Rarity of the Air arises from the Distance of the Particles, the Diameter of a Particle of Air will be to the Distance between the Centre of the Particles, as about 1 to 9 or 10; and the Distance between the Particles as 1 to 8 or 9.

Moreover, in the *Schol. gener. Sect.* 6. *lib.* 2. of the same Book, he says, he found by Experiments with Pendulums, that the Resistance of the Air is as the Square of the Velocity of a Projectile moving in it.

Those who have a mind to be more fully informed of the nature of the Air, may consult the several Writings of Mr. *Boyle*, *Marriotte*, *Paschal*, our *Philosophical Transactions*, the History and Memoirs of the Royal Academy of *Paris*, *Wolfius*'s *Aerometry*, the ingenious Dr. *Hales*'s *Vegetable Staticks*, *Boerhaave*'s *Chemistry*, and others.

Air Pump, a Machine by means of which the Air contained in any proper Vessel may be drawn out.

There have been several sorts of Air Pumps contrived and constructed from time to time from the first Invention, most of those first made consisting of but one Barrel, or hollow Cylinder of Metal, usually Brass, with a Valve at the Bottom opening inwards, and a Piston (with a Valve at the Top opening upwards) so exactly fitted to the Cavity of that Barrel, and moving therein, that when it is drawn up from the Bottom of the Barrel (by means of an indented Iron Rod or Rack affixed to it, and an Handle turning a small indented Wheel, playing in the Teeth of that Rod) all the Air will be excluded

from the Cavity thereof; and having alſo a ſmall Pipe at its Bottom, by means of which the Barrel may have a Communication with any proper Veſſel to be exhauſted of Air, the whole being affixed to a convenient Frame of Wood-Work, where the End of the Pipe turns up into an horizontal Plate or Diſh, upon which ſuch a Veſſel is placed.

Mr. *Boyle*'s Air-Pump, deſcribed in his *New Phyſico-Mechanical Experiments about the Gravity and Spring of the Air*, publiſhed *anno* 1660, has but one Barrel; ſo alſo has that which was firſt uſed by Mr. *Papin*, as likewiſe that deſcribed by *Wolfius*, in *Elem. Aerom.* But Mr. *Boyle* was the firſt who contrived and applied a mercurial Gage or Index for meaſuring the Degrees of the Air's Rarefaction or Quantity of Exhauſtion out of a given Veſſel; whoſe Deſcription he gives at the Beginning of his firſt and ſecond *Phyſico-Mechanical Continuations*. The aforeſaid Mr. *Papin* moreover was the firſt who contrived an Air Pump with two Barrels, as you may ſee in Mr. *Boyle*'s *Contin. ſecond. Experim. Nov. Phyſico-Mechan.* in *Pref. &* *Iconiſ.* 2.

But the double Barrel Air Pump of Mr. *Haukſbee*'s, publiſhed in his *Phyſico-Mechan. Exper. anno* 1709, which is now commonly uſed in *England*, far exceeds any that were ever made before, and is equal to, and, I believe, may exceed thoſe of ſome Foreigners, ſuch as *Leopold*, *s'Graveſande*, *Muſchenbroeg*, &c. that have come after him, and had each a mind to be Sharers in the Improvement of this Machine.

This double Barrel Pump is preferable to any other made before, in two things; the firſt is, That when the Receiver comes to be nearly exhauſted of its contained Air, the Preſſure of the outward Air upon the deſcending Piſton is nearly ſo great, that the Power required to raiſe the other is not much more than what exceeds the Friction of the Parts in motion; whereas in others, the nearer the Cavity of the Receiver approaches a *Vacuum*, the greater is the Labour of working them: And the ſecond, That it performs its Buſineſs in half of the time.

The Air's Elaſticity is the Foundation of this Machine: For when a Piſton is thruſt down to the Bottom of its Barrel, and then it be raiſed up, the Air in the Receiver will expand itſelf, and part of it will enter into the Barrel; ſo that the Air in the Receiver and the Barrel will have the ſame Denſity, which will be to the firſt Denſity, as the Capacity of the Receiver is to the Capacity of the Barrel and Receiver together. And by thruſting down the Piſton a ſecond time, and drawing it up, the Denſity of the Air in the Receiver and Barrel will again be leſſened in the Ratio aforeſaid; and repeating the Motion of the Piſton, the Air in the Receiver will be reduced to the leaſt Denſity, but can never be drawn all out: And if m be the Capacity of the Receiver, and n that of the Barrel, d the Denſity of the Air in the Receiver, before the Pump begins to work: Then $n+m : n :: d :$ $\frac{dn}{n+m}$ = Denſity of the Air in the Receiver at the End of the firſt drawing up of the Piſton. And $n+m : n :: \frac{dn}{n+m} : \frac{dn^2}{\overline{n+m}^2}$ = to its Denſity at the End of the ſecond Lifting up. And $n+m : n :: \frac{dn^2}{\overline{n+m}^2} : \frac{dn^3}{\overline{n+m}^3}$ = its Denſity at the End of the third Lifting up of the Piſton; and ſo on. Whereſore if s be the Number of Strokes of the Piſton, the

the Density of the Air in the Receiver at the End of those Number of Strokes will be $\frac{d n^5}{n + m^5}$ that is, in Words, *The Density of the natural Air in the Receiver is to its Density after any Number of Raisings up of the Piston, as the Capacity of the Receiver and the Cavity of the Barrel together, raised to a Power having the Number of Liftings up of the Piston for its Index, is to the like Power of the Capacity of the Receiver alone.* Which is the Theorem given by Mr. *Varignon*, in the *Memoirs de Mathemat. & Phys.* for *Dec.* 1703.

Wolfius, in his *Aerometry*, says, that the first Inventor of the *Air Pump* was *Otto de Guericke*, a Burgomaster of *Magdeburg*, who performed several Experiments with it at *Ratisbon*, in the Year 1654. before the Emperor, and several other illustrious Persons. Be this as it will, Mr. *Boyle* soon after having taken the Hint from *Schottus*'s Treatise, entitled, *Mechan. Hydraulica-Pneumatica*, published in the Year 1657. (tho' he himself, in his *Physico-Mechan. Exper.* says he did not see the Book) directed Dr. *Hook*, and another Person, to contrive a newer and better Air-Pump than *Otto de Guericke*'s, which he heard was defective, it requiring the Labour of two strong Men for more than two Hours to get the Air out of glass Vessels, plunged under Water.

The *Air-Pump* is a very useful Instrument, which from time to time has employed the Thoughts and Pains of several very ingenious and diligent Philosophers, (such as Mr. *Boyle*, Mr. *Papin*, Mr. *Haukesbee*, Dr. *Hales*, Father *Mersennus*, Mr. *Marriotte*, &c.) in making Experiments concerning the Nature and Properties of Air, and its Effects upon natural Bodies, who have every one of them obliged the World with their Labours herein. By this Instrument most of the Conclusions, but now mentioned under the Word *Air*, they have verified and confirmed, as well as a great multitude of others, which are really very curious, and wonderfully surprising. Too many to relate in this Place.

Air-Gun. See *Wind-Gun*.

Air, in Musick, is a Name given by some to any short Piece of Musick. Of these there are Sets composed by Mr. *Handel*, Dr. *Pepusch*, &c.

Ajutage, a *French* Word for the Spout of the Stream of Water in any Fountain. Here follow some Observations and Conclusions relating to Ajutages, and the Spouts of Water moving through them.

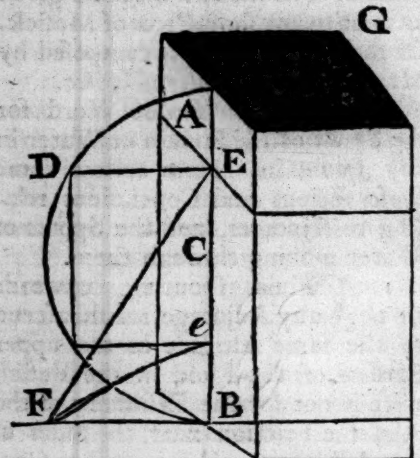
1. A Fluid spouting upwards through any Adjutage, would ascend to the same Altitude as the upper Surface of the Fluid in the Vessel, were it not for the Resistance of the Air, the Friction near the Sides of the Adjutage, and some other Causes in the motion of the Fluid itself, whereby Defects from that Altitude do always arise; which are nearly in the ratio of the Square of the Altitude of the Fluid above the Adjutage, and is to be understood of small Heights only.

2. It is found by experience, that if the Direction of the Adjutage be somewhat inclined, the Fluid will ascend higher than when it is exactly upright; and an even polished round Hole at the End of the Pipe, or Tube, will give an higher spout of Fluid than when the Adjutage is cylindrical or conical: Which last is the usual Figure, and indeed better than the cylindrical one.

3. It is found by experience, that the Bigness of the Adjutage must be inlarged where the Height of the Cistern is, and that the Pipes conveying the Water must be wide with regard to the Adjutage; and amongst the

the ſeveral Diameters of Ajutages, there is a ſtated Length in order to give the greateſt Height of the Spout poſſible, which muſt not exceed $1\frac{1}{4}$ Inch. Likewiſe the Height of the Spout of Water has its Limits, which is not much above 100 Feet.

4. If A G be a Ciſtern of Water, and the Side A B be biſſected in C, and about the Centre C, with any



Radius C E, a Semi-circle be deſcribed; and if E be an Hole or Ajutage in the Side of the Ciſtern, and E D be drawn perpendicular to A B, the Water will run out from E to F in the horizontal Plane, the Diſtance B F, which will be $=$ 2 the Perpendicular E D: So that the Water running at the Centre C will go to the greateſt horizontal Diſtance poſſible. And if C *e* be $=$ CE, the Water running out at *e* will go to the ſame Diſtance B F, as when running out at E. This Theorem is demonſtrated by ſeveral hydroſtatical Writers, amongſt which ſee Mr. *s'Graveſande's Inſtit. Philoſ. Newton. cap.* 7.

5. The Squares of the Quantities of Water running through Ajutages in any Directions whatſoever, in Ciſterns kept conſtantly full, are in the ratio of the Heights of the Surface of the Water in the Ciſtern above the Ajutage; tho' it is found by experience, that the Air's Reſiſtance, and the Friction of the Water againſt the Sides of the Ajutage, do ſomewhat diſturb this Ratio, the Quantity of Water being always leſs than what ſhould ariſe from it: But in Altitudes under 50 Feet, the Deviation is not very great.

6. The times in which cylindrical Veſſels of Water of the ſame Diameter and Height are emptied through Holes or Ajutages, are inverſely as thoſe Ajutages. And when theſe Veſſels are unequal, but the Heights and Ajutages equal, the times of emptying will be as the Baſes of the Cylinders: Therefore, in any cylindrical Veſſels, the times of emptying are in the Ratio compounded of the Baſes, the inverſe Ratio of the Diameters of the Ajutages, and the ſquare Roots of the Heights.

7. If the Side of a cylindrical Veſſel, beginning from the Baſe, be divided into Lengths, which are as 1, 2, 4, 9, 16, *&c. viz.* the Squares of the natural Numbers, 1, 2, 3, 4, *&c.* the Surface of the Water (running out through an Hole at the Bottom) will deſcend from every of thoſe Diviſions to the next in the ſame time.

8. If the Heights of two Veſſels continually full of Water be unequal, and the Ajutages alſo unequal, the Quantities of Water running out in the ſame time, are in the Ratio compounded of the ſimple Ratio of the Ajutages, and the ſub-duplicate Ratio of the Heights.

9. If the Heights of two Veſſels continually full of Water be equal, the Water will run out through Ajutages any-how unequal, with the ſame Velocity.

10. If the Height of Veſſels continually full of Water, and their Ajutages be unequal, the Velocities of the Water ſpouting out are in the ſub-duplicate Ratio of the Heights.

Moſt

Most of these Conclusions are demonstrated by Mr. *Marriotte*, in his *Traitè du Mouvement des Eaux*; as also in the abovesaid Book of Mr. *s'Gravesande*'s.

ALCOVE, a Term in Architecture, signifying a part in some Chambers, higher than the others, having an arch-like or other Figure, and separated by Pilasters, and other Ornaments; in which is placed a Bed of State, or else Seats for Entertainment. I have heard, that there are several Alcoves at the Seats of the Nobility in *Spain*, *Italy*, *France*, and some very good ones in our own Country, contrived and made by our celebrated Architects, such as *Gibbs*, *Campbell*, &c. But do not find in the Treatises of Architecture that I have seen any thing said about them, except in that of *Daviler*'s *Cours d'Architect. Tab.* 16. *p.* 177.

ALDERAIMIN, a Star of the third Magnitude on the right Shoulder of *Cepheus*.

ALDHAPHRA, a Star of the third Magnitude.

ALDEBARAN, a Star of the first Magnitude on the Head of *Taurus*, and usually called the *Bull's Eye*. Its Longitude for the Year 1700 was 5°. 49'. 30''. of *Gemini*, and Latitude 5°. 27'. 30''. *South*, according to Mr. *Flamstead*'s Catalogue.

ALEGRO, a Term in Musick, signifying that that part over which it is placed must be sung or play'd swiftly.

ALGEBRA, an universal Arithmetick, or certain kind of Logick or way of Reasoning in the Solution, Invention, and Proof of Propositions, regarding the Equality or Inequality of Numbers, or any kinds of Quantity in pure or mixed Mathematicks; and that by means of artful Dispositions, Connections and Combinations of Numbers, or the Letters of the Alphabet, (representing Numbers or Quantities, though any other Symbols would do, but not so conveniently) with Marks signifying Sums, Differences, Products, Quotients, Rectangles, &c. deduced from stated Rules; which (from some sort of Analogy they have to those of Addition, Subtraction, Multiplication, and Division in common Arithmetick) are therefore called Algebraick Addition, Subtraction, Multiplication and Division, and chiefly founded upon *Euclid*'s *Axioms* about the Addition or Subtraction of equal Numbers or Quantities, to or from equal or unequal ones; as also upon the like *Axioms* of the Equalities or Inequalities of the Products or Quotients of Numbers.

This Art is surprisingly useful in Arithmetick and Geometry, being one of the most general, extensive, short and easy Helps of discovering and proving mathematical Truths that has been hitherto invented, or perhaps ever will. By this the Solution of innumerable arithmetical Questions, which one of ever so much Skill in common Arithmetick would never be able to effect, without the utmost Pains and Trouble, and perhaps not at all, is but a mere Play; and the Reasons of all the Rules of common Arithmetick, such as Addition, Subtraction, Multiplication, Division, Extraction of Roots, Fractions, &c. do so evidently appear, and naturally flow from it, that whoever should go about to seek for others, would be said to do little else than abuse Time. This is the general Analysis that alone does assist us in finding the different Species, Figures and Properties of geometrical Curve-lines, especially those that exceed the first Order, which by any other known Means would be plainly impossible to come at (and that for want of other sufficient Elements, which I believe we shall never have, because of our Shortness of Life, small Extent of Knowledge, Nar-

rowneſs of Conception, and the Diminution of Inclination, uſually happening when our Advances in theſe Studies become great enough to make us capable of making ſuch, and rightly applying them.) In a word, by this numberleſs Problems may be ſolved, which could not any otherways be effected; and often times more Theorems are expreſſed in one Page than could be expounded and demonſtrated in whole Volumes, after any other Method.

The Word *Algebra* is derived from the *Arabick*, to which the firſt *European* Writers have aſcribed various Names, as *Reſtorationis & Oppoſitionis Regula*; that is, the Method of Reſtoration and Oppoſition. *Regula Rei & Zenſus*; that is, the Doctrine of the Root, and of the Square (*Rei* in *Italian* ſignifying a Root, and *Zenſus* its Square;) the *Coſick* Art, from the *Italian* Word *Coſa*, a Root; *l'Arte Maggiore*, or the Great Art; others, more modern, *Arithmetica Specioſa*, or Specious Arithmetick; *Logiſtica Specioſa*; *Elementa Matheſeos univerſa*, univerſal Elements of Mathematicks; the *Art of ſolving Queſtions by Equation*.

It is highly probable, that the *Indians* or *Arabians* firſt invented this Art, for it may reaſonably be conjectured, that the ancient *Greeks* knew nothing of it, becauſe *Pappus*, in his *Mathematical Collections*, in his Enumeration of their Analyſis, makes no mention of any thing like it; and beſides, ſpeaks of a local Problem begun by *Euclid*, and continued by *Apollonius*, which none of them could fully reſolve, which doubtleſs they might eaſily have done, had they known any thing of Algebra. Neither does the *Greek* way of numerical Notation ſeem at all adapted to the Purpoſes of ſuch an Art, nor their ſmall Knowledge in Arithmetick and the Properties of Numbers, imply they had any ſuch thing.

Diophantus was the firſt *Greek* Writer of Algebra. About the Year 800 he wrote thirteen Books, only ſix of which were publiſhed in *Latin* by *Xylander* in the Year 1575; and afterwards, *viz. anno* 1621, in *Greek* and *Latin* by Monſieur *Bachet* and *Fermat*, with Additions of their own. This Algebra of *Diophantus*'s only extends to the Solution of arithmetical indeterminate Problems.

Before *Diophantus*'s came out, *Lucas Paciolus*, or *Lucas de Burgo*, a minorite Friar, publiſhed a Treatiſe of *Algebra* in *Italian*, printed at *Venice anno* 1494. He may be ſaid to be the moſt ancient *European* Writer on this Art.

The Title of the Book is *Summa Arithmeticæ & Geometriæ*; and he ſays he explains it ſuch as he received it from the *Arabians*, but goes no further than ſimple and quadratick Equations: Nor does *Stifelius*, in his *Arithmetica Integra*, publiſhed *anno* 1544; *Hemiſchius*, in his *Arithmetica Perfecta*, and others, make any farther Advances. But *Scipio Ferreus* added Rules for reſolving cubick Equations, (though indeed not general ones) firſt publiſhed *anno* 1545, by *Cardan*, in *Arte Magna*. *Ludovicus Ferrarienſis*, or *Lewis* of *Ferrara*, ſhews a way how to reduce biquadratick Equations, which *Raphael Bombelli* publiſhed *anno* 1579, in his Algebra: But this is imperfect.

Tartalia was alſo another ancient *Italian* Writer upon *Algebra*. About the Year 1590, *Franciſcus Vieta*, a *Frenchman*, found out the Literary *Arithmetick*, and applied it to Algebra; and has given a very ingenious way of extracting the Roots of any Equation by Approximation, and explaining their Nature from Proportions.

Mr. *Oughtred*, in his *Clavis Mathematica*, firſt publiſhed *anno* 1631, followed and improved the ſpecious

Algebra of *Vieta*; and invented ſeveral compendious Characters to expreſs Sums, Differences, Rectangles, Squares, *&c.* But goes no further than quadratick Equations.

Before *Vieta*, ſome algebraick Writers uſed the four Letters R, Q, C, S, ſignifying the Root, (or unknown Number) Square, Cube, Surde-ſolid; or alſo for R they put N, that is, a Number. Others uſed the Characters ℞, ℨ, ℭ, ϭ, which ariſe from the Letters *r*, *z*, *c*, *s*, ſignifying (the Root, or unknown Quantity) *Rem*, *Zenſum*, (its Square) its Cube, and its Surde-ſolid. But *Vieta*, *Oughtred*, and others, put the Letter A at pleaſure for any Root, or unknown Quantity; and for the ſeveral Powers thereof they join the Letter *q* and *c* as A*q*, the Square of A, A*c* its Cube, A*qq* the ſquared Square, or fourth Power of A, and ſo on.

About this Time, or ſome few Years before, there were ſeveral other algebraick Writers; as *Nonnius*, *Ramus*, *Clavius*, *Girard*, &c. All of which, together with thoſe already mentioned, are very deficient, when compared with the Treatiſe of Algebra wrote by Mr. *Harriotte*, who died at *London anno* 1621, and publiſhed by Mr. *Warner anno* 1631; wherein he uſes the ſmall Letters inſtead of the capital ones of *Vieta* and *Oughtred*, ſhews the true Nature and Conſtitution of Equations; and gives many uſeful Theorems relating to them and their Roots, not taken notice of by any before him, moſt of which are contained in the Geometry of *Deſcartes*, firſt publiſhed in *French*, *anno* 1637; which was afterwards tranſlated into *Latin* by *Van Schooten*, a mathematical Profeſſor at *Leyden*, and publiſhed *anno* 1659, with a prolix Commentary upon it, and ſome other algebraical Pieces of other Perſons annexed; the whole affording none, or very little Improvement to the Art, except the lineal Conſtructions of cubick, biquadratick, and ſome higher Equations, by means of the Conick Sections, *&c.* which *Deſcartes* firſt ſhews how to do, may be ſaid to be ſuch.

Dr. *Pell* reviſed and altered a Piece of Algebra, firſt publiſhed in high *Dutch* at *Zurick*, *anno* 1659; and afterwards tranſlated into *Engliſh* by Mr. *Branker*, under the Title of *An Introduction to Algebra*, and publiſhed *anno* 1668. In this Dr. *Pell* gives us a particular Method of his own for applying Algebra to Problems of various kinds, and introduced the way of keeping a Regiſter of the whole Proceſs in the Margin, that ſo you may ſee how any Quantity or Equation in the large Column towards the right Hand is produced; as alſo invented ſeveral other uſeful Things.

Dr. *Wallis*, *anno* 1664, publiſhed a Treatiſe of Algebra, both Hiſtorical and Practical, containing ſeveral good Things; but not many Improvements, unleſs it be the finding the Roots of a Cubick Equation univerſally, and ſome other things about Combinations, Alterations, and aliquot Parts.

Mr. *Kerſey*, *anno* 1671, publiſhed a Folio Treatiſe of Algebra, explaining the Nature of Equations, and illuſtrating his Precepts with plenty of Examples. He explains *Diophantus* throughout, and gives many things out of *Marinus Gethaldus de Reſolutione & Compoſitione Mathematica*. Monſieur *Preſtet*, a *Frenchman*, publiſhed much ſuch another Treatiſe *anno* 1694. Alſo Monſieur *Ozanam*, publiſhed *Elements of Algebra anno* 1703, in *French*, wherein, beſides the literal Calculus, and the Doctrine of Equations, he wonderfully illuſtrates the *Diophantean* Doctrine of reſolving numerical Problems, in which this Author has chiefly excelled. And a

Compendium of Mr. *Prestet* was printed *anno* 1704, by Mr. *Lamy*, with the Title, *Elemens de Mathematique*; which, by reason of its Perspicuity, may be esteemed a fit Piece for Learners, though he does not touch upon the *Diophantean* Doctrine.

Monsieur *Ozanam*, in his *French* Treatise of *Geometrick Loci*, as also Monsieur *De la Hire* and *Guisnee*, have applied Algebra to Geometry, as well as the Marquis *de l'Hospital*, in his *Conick Sections*, and several other Authors, too many to mention. But we must not pass by a neat Piece of Algebra, published in *Dutch*, *anno* 1661, by Mr. *Kinckhuysen*, wherein the Rules of Algebra are perspicuously explained, but without Examples; the chief Properties of the *Conick Sections* algebraically investigated, and many elegant Constructions of geometrical Problems found out by Algebra are laid down. The worth of this Tract will pretty evidently appear, if we consider that Sir *Isaac Newton*, formerly, when he was Professor of Mathematicks at *Cambridge*, thought it not beneath his Pains to complete and adorn it, and add to the same his Method of *Infinite Series and Fluxions*, which he had almost prepared for the Press; as we learn from Mr. *Collins*'s Letters to Mr. *Borellus* and Mr. *Vernon*, to be found in the *Commercium Epistolicum de varia re Mathematica*, published by order of the Royal Society.

In *Degraave*'s *Course of Mathematicks* in *Dutch*, there is a pretty Piece of Algebra. There is also *Baker*'s *Geometrical Key*, containing the Constructions of cubick and biquadratick Equations.— Mr. *Ralphson*'s *Universal Analysis of Equations*.— *Reynau*'s *Algebra*, published *anno* 1707, contained in his *Analyse demontré*, a heavy, tedious Piece, though containing some good Things.— *Jones*'s *Synopsis*, published *anno* 1706, does likewise neatly treat of *Algebra*.— There is also *Ward*'s *Algebra*, well enough for some to learn from.— But amongst all the Pieces on this Subject, the *Universal Arithmetick* of Sir *Isaac Newton*, which were Lectures formerly read by him at *Cambridge*, when he was *Lucasian* Professor, and published by Mr. *Whiston*, *anno* 1707, is by far the best; and would be a complete thing, if to the same were added Sir *Isaac*'s Method of extracting the Roots of Equations by infinite Series, which we have in the *Commercium Epistolicum*, and the *Fragmenta Epistolarum*, published by Mr. *Jones*, *anno* 1711; and also the Artifice of managing unlimited Problems, which no doubt he would have done, had he ever designed it for the Publick.— What is eminent in this Treatise, and no where else to be met with before, are his excellent Choice of Problems, uncommon Skill in their Solution, and great Dexterity in some of their Constructions: Also his Rules for finding Divisors to compound Quantities; — for reducing radical Expressions to more simple ones, by the Extraction of Roots; —for exterminating unknown Quantities from two or more compound Equations; — for making Choice of such and such Lines, rather than others, in the Solution of geometrical Problems, to get the most simple Equation; — for finding the imaginary Roots of an Equation; — for finding the Limits of the Roots; — for finding whether an Equation of four, six, or more Dimensions, may not be reduced: — And his Method of applying Algebra to the Description of the *Conick Sections* through given Points, and to touch given Lines, are all what no one else could ever give, and are perfectly correspondent to the Genius of that wonderful Person.

There

There are many other Treatises of Algebra, such as *Rohnane*'s, containing many good Things, all mere Collections. *Wolfius*'s, in his *Elements of Mathematicks*, *s'Gravesande*'s, and others, too numerous to mention, as well as unnecessary. You have also several little Discourses here and there dispersed in the *Philos. Trans.* of *London*, *Paris*, *Berlin*, *Petersburgh*, as so many Attempts to improve and bring Algebra to its utmost Perfection.

ALGEBRA *Numeral*, is that which gives the Solution of arithmetical Problems, in Numbers only; such as that of *Diophantus*, *Lucas de Burgo*, *Steifel*, and others of the Ancients.

ALGEBRA *Specious*, is that which is formed by the Letters of the Alphabet, first introduced by *Vieta* and *Harriot*; and is far more general than numerical *Algebra*, being no ways limited to any certain sort of Problems: And no less useful in finding out any kind of Theorems, than in discovering the Solutions and Demonstrations of Problems; as may be seen in Treatises upon this Subject.

ALGEBRAICK *Curve*. See *Curve*.

ALGENEB, a fixed Star of the second Magnitude, on the right Side of *Perseus*.

ALGOL, a fixed Star of the third Magnitude, also called *Medusa*'s *Head*, in the Constellation *Perseus*.

ALGORITHM, the four chief Rules of Arithmetick, *viz.* Addition, Subtraction, Multiplication, and Division.

ALIDADA, an *Arabick* Name for the Label or Ruler which is moveable about the Centre of an Astrolabe, Quadrant, &c. and carries the Sights of a Telescope.

ALIQUANT PART, is that Number which cannot measure any Number exactly without some Remainder, as 7 is an aliquant Part of 16; for twice 7 wants 2 of 16, and three times 7 exceeds 16 by 5.

ALIQUOT PART of a *Number*, is such an one as will exactly measure it without any Remainder, as 2 is an aliquot Part of 4, 3 of 9, 4 of 16, &c.

All the aliquot Parts of any Number may be found by the following Rules: Divide the given Number by its least Divisor, and the Quotient by its least Divisor, until you get a Quotient that cannot be further divisible, and you will have all the prime Divisors, or aliquot Parts of that Number; then, if every two, three, four, &c. of these Divisors be multiplied into themselves, the Products will be the several conjoined Divisors, or aliquot Parts of that Number. As suppose you want all the aliquot Parts of 60, divide it by 2, and the Quotient 30 by 2, and the Quotient 15 by 3, and there remains the indivisible Quotient 5: Therefore all the prime aliquot Parts are 1, 2, 2, 3, 5; and the compound ones from the Multiplication of every 2, are 4, 6, 10, 15, and from that of every three, 12, 20, 30. In like manner, the aliquot Parts of 360 will be found to be 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, 36, 40, 45, 60, 72, and 180; for all the prime aliquot Parts are 1, 2, 2, 3, 3, 5; and those from the Multiplication of every 2 of these are 4, 6, 9, 10, 15; those from every 3 are 8, 12, 18, 20, 30, 45; those from every 4; 24, 36, 40, 60, 90; and those ftom every 5; 72, 120, 180.

ALLIGATION, one of the Rules in Arithmetick, being so called from the Numbers being bound or connected together by circular Lines, relating to the Mixture of Corn, Wine, Sugar, Metals, or any other Things of different Prices; shewing how to find such Quantities of given Prices, that when mixed, any given Quantity of the Mixture shall have a given intermediate Price. As suppose

pose a Mixture of 100 Pounds of Sugar, was required, which should be worth 12 Pence a Pound, and that Mixture was made up of four sorts of Sugar, at 6, 10, 15, and 17 Pence per Pound; to find how much of each kind of Sugar is necessary to that Composition.

The Rule is, place all the Prices (except the main one) one under another, and let every Number less than the mean one, be linked to one greater, then take the Difference of each Number from the mean Price, and place this Difference against the Number it is linked to alternately: But every Number linked to more than one, must have all the Differences of the Numbers it is linked to, set against it. This done, as the Sum of all the Differences is to the whole given Mixture, so is any Difference to a fourth Number; being the required Quantity of that Thing which stands against that Difference. Thus in the Case above.

	6	3	27	Pounds of each
	15	6	54	
12				
	10	5	45	
	17	2	18	
		16	144 Pounds.	

that is, 27 Pound of that of 6 Pence, 54 of that of 15 Pence, 45 of that of 10 Pence, and 18 of that of 17 Pence.

Note, as there may be several Varieties of Linkings to the same given Prices, there will arise from the Rule so many several Answers to the same Question. But in Reality all the Questions within the Bounds of this Rule, are unlimited, being capable of an Infinite Number of Answers; and the easiest and plainest way of resolving all such is by common Algebra, which any one of but a very slender Skill in the same, will easily know how to do.

Those who have a mind to see more of the Rule of Alligation, with its Demonstrations, may consult Dr. *Wallis*, *Taquet* in his Arithmetick, and particularly the ingenious Mr. *Malcolm*'s System of *Arithmetick*.

ALMAGEST, an Arabick Name of a Treatise of Astronomy written by *Ptolemy*: As also of another Piece upon the same Subject by *Ricciolus*.

ALMACANTOR, is a Circle of the Sphere passing thro' the Centre of the Sun or a Star parallel to the Horizon, being the same as a Parallel of Altitude. Which see. The Word is Arabick. Some call it *Almicanter*, and others *Almucanter*.

ALMICANTER'S Staff, an Instrument (of no great Account) formerly used by some at Sea, being made of Pear-Tree or Box, containing an Arch of 15 Degrees, serving to observe the Degrees of the Sun's Amplitude at Sea.

ALMANACK, an Arabick Word for several annual Books, or Sheets of Paper, publish'd under various Names, with various Matters contain'd. In most of which you have the Days of the Month, the Eclipses, the Age of the Moon, Times of high Water, rising and setting of the Sun, Festivals, &c.

ALTERNATE RATIO, is the Ratio of Antecedent to Antecedent, as Consequent to Consequent, in any Proportion. As if it be as A : B : : C : D, then will the Ratio of A to C, equal to the Ratio of B to D be *alternate*; so that this Sort of Ratio only takes place when the Quantities in a Proportion are of the same kind.

ALTERNATE ANGLE. See ANGLE.

ALTERNATION, of Quantities, is the Number of ways that they may be varied, changed, or differently placed. As suppose the Quantities were *a*, *b*, *c*, &c. then will all their Varieties,

Varieties of Order be *a b c*, *a c b*, *b a c*, *b c a*, *c a b*, *c b a*, viz. 6: And if n be the Number of Quantities, the Number of Alterations will be $n \times \overline{n-1} \times \overline{n-2} \times \overline{n-3}$, &c. to $\overline{n-n}$, that is, it will be had by the continual Multiplication of the Number of Things by the ſeveral natural Numbers gradually decreaſing from it to unity. As ſuppoſe it be required to find the Changes of 12 Bells, the ſame will be $12 \times 11 \times 10 \times 9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 479001600$. But if the ſame Quantity occurs ſeveral Times ſuppoſe it be repreſented by m, then will the Number of Variations be

$$\frac{\overline{n-1} \times \overline{n-2} \times \overline{n-3} \times \overline{n-4}, \text{ \&c.}}{\overline{m-1} \times \overline{m-2} \times \overline{m-3} \times \overline{m-4}, \text{ \&c.}}$$

that is, continuing on the Series, until the continual Subtraction of 1 from n and m leaves o.

This Rule is given by many Writers in Algebra or Arithmetick; as Dr. *Wallis*, *Wolfius*, *Jones*, *Malcolm*, &c. and the Invention is inferred from an Induction of the ſubordinate particular Caſes, as when there are 2 Quantities *a* and *b*, they may either be wrote *ab* or *ba*; ſo that the Number of Variations will be $2 = 2 \times 1$. When there are three Quantities *a*, *b*, and *c*, it is evident that one as *c*, may be combin'd firſt with *ab*, and then with *ba*; ſo that the Number of Variations or Alternations will be $3 \times 2 \times 1 = 6$. If there be four Quantities, every one of them may be combined with any Order of three of them, ſo that the Number of the Alternations will be $6 \times 4 = 4 \times 3 \times 2 \times 1 = 24$. So alſo if there be five Quantities, every one of them join'd with any Order of four of thoſe Quantities, produces 5 Variations; wherefore the Number of all the Alternations will be $24 \times 5 = 5 \times 4 \times 3 \times 2 \times 1 = 120$: And ſo generally if n be the Number of Quantities, the Number of Alternations will be $n \times \overline{n-1} \times \overline{n-2} \times \overline{n-3}$ &c. as above. In like manner is deduced the general Rule when the ſame Quantity is more than once repeated.

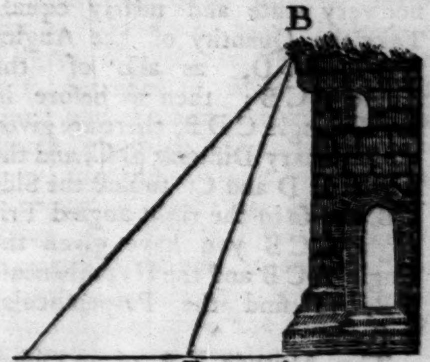
ALTIMETRY, a Name given by ſome to that Part of practical Geometry which ſhews how to meaſure the *Heights* of Objects; ſuch as Towers, Steeples, Hills, Clouds, &c. both acceſſible and inacceſſible.

ALTITUDE or HEIGHT, of any Point of a terreſtrial Object, is a Perpendicular let fall from that Point to the Plane of the Horizon.

ALTITUDE INACCESSIBLE, of an Object, is ſuch an one as cannot be approach'd by reaſon of ſome Impediment.

This may be found ſeveral ways: the beſt and moſt uſual of which are from two Stations on the horizontal Plane, and by means of the Barometer: Both of which are pleaſant and uſeful.

Suppoſe it were required to meaſure the Altitude or Height AB of a ruinated Tower. To do this, I make choice of two Stations

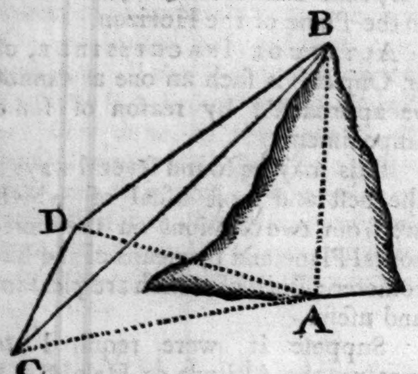


D and C, in the ſame right Line with A, and whoſe Diſtance DC is ſuch, that the Angle CBA be not too ſmall, nor the Station C too near to AB; then I meaſure the

ſtationary

ſtationary Diſtance D C, and the Angles B D A, B C A. This done in the Triangle B D C, there are given the Side D C, and the adjacent Angles at D and C, to find the Side C B; and then in the right angled Triangle C B A, the Hypotheneuſe C B is given, and the Angle B A C to find the Perpendicular A B; to which, if the Height of the Eye be added, you will have the true Height of the Tower.

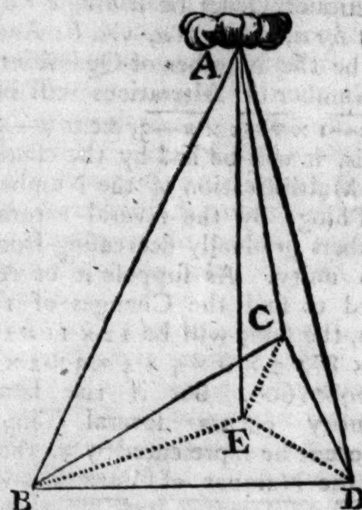
A little otherwiſe. When the ſtationary Diſtance C D is not in the



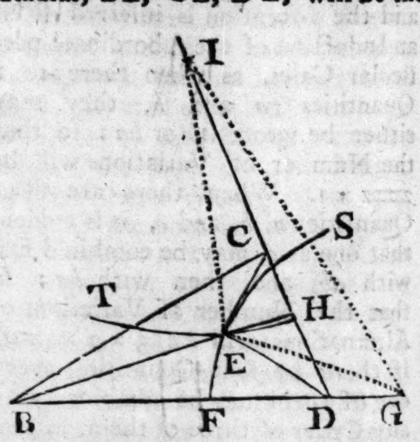
ſame Plane with the Altitude A B, let the Angles A D C, A C D, be not very acute and nearly equal. Take the Quantity of the Angles B D C, B C D, as alſo of the Angle A C B; then as before in the Triangle C D B, there are given the ſtationary Diſtance D C, and the Angles at D and C, to find the Side C B, and ſo in the right angled Triangle A C B you have given the Angle A C B and the Hypotheneuſe C B, to find the Perpendicular A B.

The Altitude E A of an Object any how moving in the Air; as ſuppoſe of the Cloud A, may be found from three Stations, B, C, D, upon the horizontal Plane, after the following Manner.

Let three Perſons at the Stations B, C, D, take at the ſame time with



Quadrants or other proper Inſtruments the Meaſures of the Angles A B E, A D E, A C E. This done, from the three given Angles, and the given Stationary Diſtances B C, C D, B D, the deſir'd Altitude E A may be thus found. If A E be the Radius, B E, C E, D E, will be the



Co-Tangents of the given Angles of Obſervation A B E, A C E, A D E, and ſo theſe Co-Tangents are given, and the Ratios of B E, E C, E D, are given. Divide B D in the Point F in the given Ratio of the Co-Tangent of the Angle A B E, to the Co-Tangent of A D E, and continuing out B D, make as F G : F D : : B F : B F—F D, and from G deſcribe the circular

circular Arch FES: Also divide DC in the Point H, in the given Ratio of the Co-Tangent of the Angle A D E to the Co-Tangent of the Angle ACE, and continuing out DC, make HI : HC :: HD : HD—HC, and from I describe the Arch HET, intersecting the former Arch in the Point E. Then if right Lines B E, CE, D E be drawn, and with either of them as a Base, and with the correspondent Angle of Observation, you make a right angled Triangle, the perpendicular of that Triangle will be the Altitude required.

The Measures of the Lines CE, or ED, may be computed thus, Draw the Lines EI, IG. In the Triangle DIG, there are given two Sides DG, DI, and the included Angle IDG, *viz.* the Complement of the given Angle BDC to two right Angles. Therefore find the third Side GI, and the Angle DIG; then in the Triangle GEI, there are given the three Sides GE, EI, IG, to find the Angle EIG. When you have the Measure of this Angle, take it from that of the Angle DIG, and you will get the Angle EIC. This done in the Triangle EIC, there are given two Sides, EI, CI, and the included Angle EIC, to find the third Side EC; after which in the right angled Triangle ACE, (Fig. 1.) right angled at E, you have given the Base CE, and the Angle ACE, to find the Perpendicular AE.

Note, If BF be greater than FD, or DH than HI; the Centres G, I, must be taken towards the Points B and D, and if BF be=FD, and DH=HC; instead of the circular Arches FES, HET, you must draw right Lines from the Points F, H, perpendicular to BD, CD, and their Intersection will give the Point E, as before.

Note, When the Height of an Object is so great as to have a sensible Proportion to the Semidiameter of the Earth, such as, for Instance, is that of the Moon, the Methods aforesaid will be ineffectual, because the stationary Distance here being so great to cause a due Difference in the stationary Angles, (I speak of the first Method) becomes the Arch of a Circle of the Earth, instead of a right Line, as indeed is any stationary Distance; but then when it is short, the circular Arch, of which it is a Part, may be taken for a right Line.

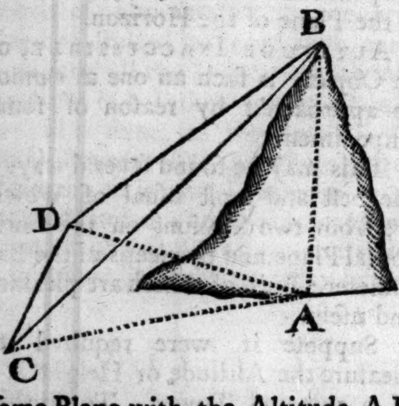
The way of taking considerable terrestrial Altitudes, of which those of Mountains are the greatest, by means of the Barometer, is very pretty and expeditious. This is done by observing on the Top of the Mountain, how many Inches and Parts of an Inch the Mercury has fell below what it was at the Foot of the Mountain. When this is done, you will have its Altitude in English Feet, by means of the Table of Mr. *Cassini*. (See *Hist. de l'Acad. Roy.* 1703, and 1705,) which he founded upon very accurate Mensurations of the Altitudes of several Mountains.

There are other ways of measuring Altitudes by having given the Degrees of Distance, that the same first becomes in sight (usually at Sea,) and the Semidiameter of the Earth, of which, if you please, you may have an Account in Books of Geography, such as *Varenius* at *Chap.* 11. *Part* 1. You have also a pretty Discourse in the *Philosophical Transactions*, N. 405, by Mr. *Schutzer* upon the Altitudes of Mountains, and the Ways of finding them by the Barometer, where you have Tables of three different Persons, *viz.* Mr. *Marriotte*, *Cassini*, and himself, for that purpose.

Altitude, *of a Cylinder* or *Prism*, is a perpendicular Line drawn from one Base to the other.

ſtationary Diſtance DC, and the Angles B D A, B C A. This done in the Triangle B D C, there are given the Side D C, and the adjacent Angles at D and C, to find the Side CB; and then in the right angled Triangle C B A, the Hypotheneuſe C B is given, and the Angle B A C to find the Perpendicular AB; to which, if the Height of the Eye be added, you will have the true Height of the Tower.

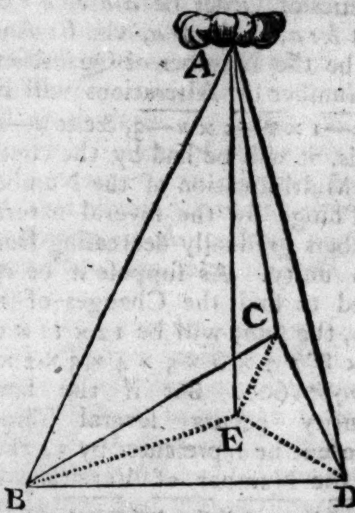
A little otherwiſe. When the ſtationary Diſtance CD is not in the



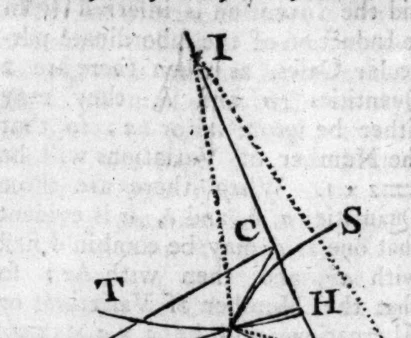
ſame Plane with the Altitude A B, let the Angles A D C, A C D, be not very acute and nearly equal. Take the Quantity of the Angles B D C, B C D, as alſo of the Angle A C B; then as before in the Triangle C D B, there are given the ſtationary Diſtance D C, and the Angles at D and C, to find the Side C B, and ſo in the right angled Triangle A C B you have given the Angle A C B and the Hypotheneuſe C B, to find the Perpendicular A B.

The Altitude E A of an Object any how moving in the Air; as ſuppoſe of the Cloud A, may be found from three Stations, B, C, D, upon the horizontal Plane, after the following Manner.

Let three Perſons at the Stations B, C, D, take at the ſame time with



Quadrants or other proper Inſtruments the Meaſures of the Angles A B E, A D E, A C E. This done, from the three given Angles, and the given Stationary Diſtances B C, C D, B D, the deſir'd Altitude E A may be thus found. If A E be the Radius, BE, CE, D E, will be the



Co-Tangents of the given Angles of Obſervation A BE, A C E, A D E, and ſo theſe Co-Tangents are given, and the Ratios of B E, E C, ED, are given. Divide B D in the Point F in the given Ratio of the Co-Tangent of the Angle A B E, to the Co-Tangent of A D E, and continuing out B D, make as F G : F D : : B F : B F—F D, and from G deſcribe the circular

circular Arch FES: Also divide DC in the Point H, in the given Ratio of the Co-Tangent of the Angle A D E to the Co-Tangent of the Angle ACE, and continuing out DC, make HI : HC :: HD : HD—HC, and from I describe the Arch H E T, intersecting the former Arch in the Point E. Then if right Lines B E, C E, D E be drawn, and with either of them as a Base, and with the correspondent Angle of Observation, you make a right angled Triangle, the perpendicular of that Triangle will be the Altitude required.

The Measures of the Lines C E, or E D, may be computed thus, Draw the Lines E I, I G. In the Triangle D I G, there are given two Sides D G, D I, and the included Angle I D G, *viz.* the Complement of the given Angle B D C to two right Angles. Therefore find the third Side G I, and the Angle D I G; then in the Triangle G E I, there are given the three Sides GE, E I, I G, to find the Angle E I G. When you have the Measure of this Angle, take it from that of the Angle D I G, and you will get the Angle E I C. This done in the Triangle E I C, there are given two Sides, E I, C I, and the included Angle E I C, to find the third Side E C; after which in the right angled Triangle A C E, (Fig. 1.) right angled at E, you have given the Base CE, and the Angle A C E, to find the Perpendicular A E.

Note, If B F be greater than F D, or D H than H I; the Centres G, I, must be taken towards the Points B and D, and if B F be=F D, and D H=H C; instead of the circular Arches F E S, H E T, you must draw right Lines from the Points F, H, perpendicular to B D, C D, and their Intersection will give the Point E, as before.

Note, When the Height of an Object is so great as to have a sensible Proportion to the Semidiameter of the Earth, such as, for Instance, is that of the Moon, the Methods aforesaid will be ineffectual, because the stationary Distance here being so great to cause a due Difference in the stationary Angles, (I speak of the first Method) becomes the Arch of a Circle of the Earth, instead of a right Line, as indeed is any stationary Distance; but then when it is short, the circular Arch, of which it is a Part, may be taken for a right Line.

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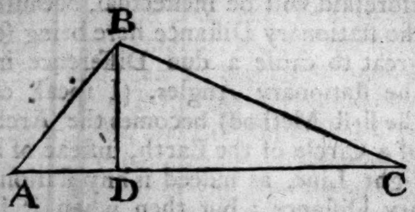
ALTITUDE, *of a Cylinder* or *Prism*, is a parperdicular Line drawn from one Base to the other.

Altitude *of a Figure*, is the Perpendicular, drawn from the Vertex of the Base, as the right



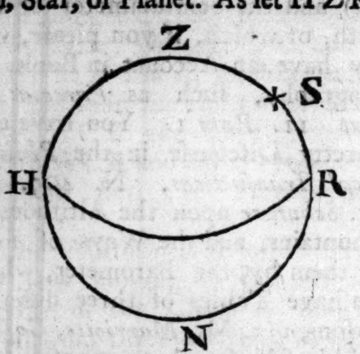
Line BD, drawn from the Vertex B, of the Triangle ABC, perpendicular to the Base AC, is the Altitude of the Triangle.

The heights of Figures must be known, in order to have their Areas and Solidities.

Altitude *of the Sun, Star, Planet*, or any Point in the Heavens, is an Arch of a vertical Circle, passing thro' the Centres of the Sun, Star, Planet or Point, contained between the Horizon and their Centres.

These are found by large Quadrants, Sextants, or Gnomons. See *Hevelius Machin. Cœlest.* Tom. 1. *De la Hire's Tab. Astron. Bion* on *Mathem. Instruments. Wolfius's Elem. Astron.* and other Authors.

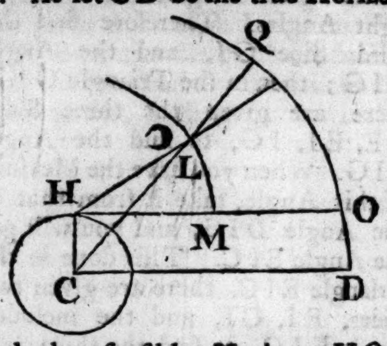
Altitude *Meridian* of the Sun, Star or a Planet, is an Arch of the Meridian, intercepted between the Horizon and the Centre of the Sun, Star, or Planet. As let HZRN



be the Meridian, HR the Horizon, and let there be a Star at S; then is RS the Meridian Altitude of that Star.

The finding the Meridian Altitude of the Sun or Stars, is the Basis of all astronomical Observations, and cannot be made with too much Care and Exactness. It is usually done with large Quadrants, Sextants, *&c.* Some of the Ancients, and Moderns too, have used high Poles for this Purpose. *Ricciolus*, in his *Astron. Reform.* says, that *Ulugh Beigh*, a King of *Parthia* and *India*, about the Year 1437, used a Pole above 180 Roman Feet high, and Mr. *Cassini*, in the Church of *St. Petronius* at *Bononia* (in the Year 1655) another of 20 Feet.

Altitude *Apparent*, of any Point in the Heavens, is the Arch of a vertical Circle contain'd between the sensible Horizon, and the vertical Circle, in which that Point is. As let CD be the true Horizon,



and the sensible Horizon HO, a vertical Circle DQ, whose Centre is C, the Centre of the Earth; and let L be any Point in the Heavens; let H be the Place of Observation, and LM an Arch of a Circle, drawn thro' L about the Centre H; then is LM the apparent Altitude of the Point L, which is always less than the

True *Altitude*, which is the Arch QD of a vertical Circle, whose Centre is the Centre C of the Earth.

The True Altitudes of the Sun, fixed Stars and Planets, do differ but a very small Matter from their apparent Altitudes, by reason of their great

great Distances from the Centre of the Earth, and the smallness of the Semidiameter of the Earth, when compared thereto. But the true and apparent Altitudes of the Moon do differ, and that about 52 *Minutes*.

ALTITUDE *of the Cone of the Earth's Shadow*, is found when the Sun is at a mean Distance, by saying as the apparent Semidiameter of the Sun, *viz.* about 16 is to Radius, so is the Semidiameter of the Earth, to a fourth Proportional 214.8 Semidiameters of the Earth, which will be the Altitude sought for. But when the Earth is most distant from the Sun, its apparent Semidiameter will be 15′ 50″, and then the Altitude of the Cone will be 217 Semidiameters of the Earth.

The Altitude of the Cone of the Earth's Shadow, is to that of the Shadow of the Moon, as 10 to 28, which is the Ratio of the Diameter of the Earth to that of the Moon.

ALTITUDE, or *Elevation of the Pole*, is an Arch of the Meridian intercepted between the Horizon and either of the Poles of the World.

This is equal to the Latitude of the Place, and may be found from the Meridian Altitudes of the Pole-Star, it being ½ the Distance of these Altitudes added to the lesser Altitude, or else by Means of the Sun's Altitude, and Declination.

ALTITUDE or *Elevation of the Equator*, is the Arch of a Meridian intercepted between the Horizon and the Equator, being always equal to the Complement of the Latitude.

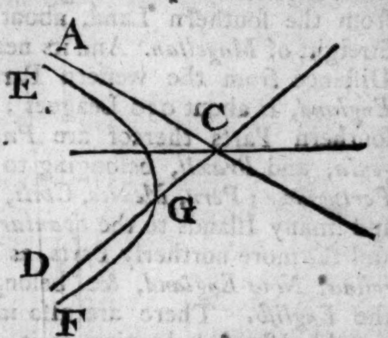
ALTITUDE *of the nonagesimal Degree*, is the Altitude of the nonagesimal Degree, reckon'd from the Point at which it rises: or it is the Complement to a Quadrant of the Distance of the nonagesimal Degree from the Vertex of any Place.

The manner of finding this at a given Time, in a given Latitude, may be found in Books of Astronomy, amongst which, see *Wolfius*'s *Elem. Astron. N.* 211, 212.

ALTITUDE *of the Eye*, in Perspective, is a right Line let fall from the Eye, perpendicular to the geometrical Plane, being the Point from whence the principal Ray proceeds.

AMBIENT, encompassing round about. As the Bodies that are placed about any other Body, are called *Ambient* Bodies, and sometimes *Circum-ambient* Bodies; and the whole Body of the Air, because it encompasses all things on the face of the Earth, is call'd the *Ambient Air*.

AMBIGENAL HYPERBOLA, a Name given by Sir *Isaac Newton*, in his *Enumeratio Linearum Tertii Ordinis*, to one of the Triple Hy-



perbola's of the second Order, having one of it's infinite Legs falling within an Angle form'd by the Asymptotes, and the other falling without that Angle; as let A C, C D be two Asymptotes, and E G F one of these Hyperbola's; then if the infinite Leg G E falls within the Angle A C D, and the Infinite Leg G F without that Angle, the said Hyperbola is call'd *Ambigenal*.

AMBIT *of any Figure* in Geometry, is the Line or Lines by which the same is bounded.

AMBLIGONAL, among the ancient Geometricians, signifies *Obtusangular*; as a Triangle or other plain Figure, that has one obtuse Angle,

Angle, is ſaid to be *Obtuſ-angular*.

AMERICA, one of the four Parts of the Earth, greater than the other three. It lies in Length from South to North, under the Shape of two vaſt Peninſulas, join'd together by the Streights of *Panama*, where the Land is not above 17 Leagues from Sea to Sea. It is bounded on the Weſt by the Pacifick Ocean, on the Eaſt by the Atlantick Ocean, and on the South by the Streights of *Magellan*. But its northern Bounds are not yet diſcovered, at leaſt beyond *Davis*'s Streights, nor is it known whether it joins to the North Parts of *Europe*, or is ſeparated from them. It's utmoſt ſouthern Bound is Cape *Horn*, in the Latitude 57° 30′. It's leaſt Diſtance from *Aſia* is about the Streight of *Anian*; from *Groen-Land* about *Davis*'s Streight; and from the ſouthern Land, about the Streight of *Magellan*. And its neareſt Diſtance from the weſtern Part of *England*, is about 950 Leagues; the ſouthern Parts thereof are *Pantagonia*, and *Brazil*, belonging to the *Portugueze*; *Peru*, *Mexico*, *Chili*, &c. and many Iſlands to the *Spaniards*; and the more northerly Parts, as *Carolina*, *New-England*, &c. belong to the *Engliſh*. There are alſo innumerable Iſlands belonging to it.

America was unknown to the Antients; the following ſhort Account of the Diſcoveries of it, and its Parts, tho' a little foreign to our Deſign, take as follows.

A *Portugueze* Veſſel, going to the *Eaſt-Indies*, was by ſtreſs of Weather drove upon the Coaſt of *Ponant*, and ſhe found her ſelf near this Country. All the Crew periſhed through Hunger and Want, except one Pilot and four Sailors, who being return'd to a Port of the Iſland of *Madeira*, full of Fatigue and Miſery, died in a little time after, at the Houſe of one *Chriſtopher Columbus*, a *Genoeſe* by Birth, who was a Sailor in that Iſland; to whom they had given an Account of their Voyage, and the Country they had diſcovered. *Columbus* applied for Aſſiſtance to diſcover this Country to *Alphonſus* the 5th, King of *Portugal*, and *Henry* the 7th, King of *England*, who rejected his Propoſal, thinking it a mere Dream. In the Year 1486, he communicated his Deſign to ſeveral Perſons of the *Spaniſh* Court, they too thought his Requeſt to be vain and extravagant; till at laſt *Alphonſus De Quintavile*, Great Treaſurer of *Spain*, and Cardinal *Gonzales de Mendoſa*, Archbiſhop of *Toledo*, making a favourable Relation of his Affair to the King and Queen of *Spain*, promiſed to aſſiſt him in it ſo ſoon as the War which the *Spaniards* had with the *Moors* was ended. And accordingly he began his Voyage the third Day of *Auguſt*, in the Year 1492, and on the 11th of *October* he diſcovered the Iſland of *Jamina*, one of the Sugar-Iſlands, afterwards called *Cuba*, and landed in the Iſland called the *Spaniſh Iſland*. Returning into *Spain*, he was very well received, and made Admiral of all thoſe Seas. In the Year 1493, he went a ſecond time from *Spain* with 18 Sail, and found out the Iſland of *Deſire*, all the northern Coaſt of the Iſland of *Cuba*, the Iſlands of *Jamaica*, and *Boriguen*, and other ſmall neighbouring Iſlands. In the Year 1497, he made another Voyage, in which he diſcovered the Gulph of *Paria*, about 450 Leagues off the Coaſt to Cape *de Vela*, and the Iſland of *Cubaga*, famous for the great Quantities of Pearls found therein. In the ſame Year *Sebaſtian Cabot* diſcovered *New-England*. In the Year 1499, *Pierre Alphonſo Nigno*, a Spaniard, diſcovered the Countries of *Cumana* and *Curiana*. The ſame Year *Diego Lopez* a Spaniard, diſcovered the Coaſt from the Mouth of the *Amazons*,

zons, to Cape St. *Augustine*. In the Year 1500, *Vincent Yanes Pinsen*, a *Spaniard*, discovered the several Inlets of the great River of the *Amazons*; and *Gasper Cortel Real*, a *Portugueze*, the Gulph of *St. Laurence*, and the Island of *Terra Nova*. In the Year 1522, *Columbus* discovered the Coast from the River *Hiquras* to *Nombre de Dios*, and the Coast of *Veragua*. Also the same Year *Roderic de Battidas* a *Spaniard*, discovered 200 Leagues of the Coast from *Cape de Vola* to the Gulph of *Uraba*. In the Year 1508, *Diego Niquesa*, a *Spaniard*, discovered about 90 Leagues of the Coast, from *Nombre de Dios*, to the Rocks of *Darien*. In 1512, *John Dias de Solis*, a *Portugueze*, found out the Coast of *Brazile*, from Cape *St. Augustine*, to the River *De Plata*. In the same Year, *John Ponce de Leon*, found out the Coast of *Florida*. In 1513, the 25th of *September*, *Vasco Nugnes de Vascoa*, a *Spaniard*, discovered the South Sea, and afterwards the western Coast of *Golden Castile*. In 1517, *Francis Harmandies de Corduba*, a *Spaniard*, found out the Coast of *Jutican*, and *John de Grailva* the Coast of *Tabasco*, to *St. John de Ulna*; also *Francis Garay*, a *Spaniard*, discovered the Coast from *Florida* to *Panuco*. In 1519, *Francis Magellan*, a *Portugueze*, discovered the Streight of that Name. In 1520, *Lucas Vasques* a *Spaniard* discovered the Coast between Cape *St. Helen* and the River of *Jourdan*. In 1521, *Ferdinand Magellan* found out the Islands of *Ladrones*. In 1523 and 1524, *John Verazan*, a *Florentine*, discovered the Coast from *Florida* to the 40th Degree of Latitude, in the Name of the King of *France*: The same Year *Roderic de Battidas*, a *Spaniard*, found out the Country of *St. Martha*. In 1525, *Gonzales Ximenes*, a *Spaniard*, discovered *New Granada*; and *Francis Pizarra*, found out the Coast of *Peru*. In 1528, *Ambrose Dolphinger*, discovered the Coast of *Venesvela*, in the Name of the Emperor *Charles* the V. In 1531 *Ferdinand Cortez*, found out *Chiametlan*, *Xalisco*, *Cinaloa*, and *Culiacan*. In 1534 and 1535, *James Quartier* of *St. Malo*, discovered all the Coast of *Canada*, reaching from the Mouth of the northern Inlet of the great River of *Canada*, to the River of *Iroquois*, and from the eastern Coast to the Gulph *de Chateaux*. In 1535, *Pierra de Mendoza*, a *Spaniard*, found out a great part of the Inlets into *Rio de Plata*: And *Almagro* found out the Coast of *Chili*. In the Year 1538 *Marke de Niza*, a *Spaniard*, discovered the Coast of *Cinola*, and *California*. In 1541, *Francis Vasques* found out the Province of *Quirini*.

The Historians of this Country are very numerous, some of them are, *Acosta*, *Herera*, *De Laet*, *Diaz*, *Gage*'s Survey, *Antonio de Solis*'s Account of the Conquest of *Mexico*, *Alexander Ursina*, *Casas*, *Conquesta del Peru* by *Augustine de Zorata*; *Vega*'s, *Cieza*'s, and *Acarete*'s Description of that Country, *Seppe*'s, and *del Techo*'s Voyage to *Paraguay*, *Alonso de Ovale*'s History of *Chili*, *Ogilby*'s *America*, all relating to the *Spanish* Possessions. And for the *French* Settlements in North *America*, you have *Champlain*, *Geuxius*, and *Mont*, to *Canada*; *Fernand*, *Soto*, and *Navraez*, to *Florida*; *de la Salle*, *de la Hontain*, and Father *Henepin*'s Travels into North *America*. Also *Newhoff*'s Description of *Brazil*, is well enough for the *Dutch* and *Protugueze* Acquisitions there. For the *British* Part, see the *British* Empire in *America*, *Smith*'s Account of the first *English* Plantations in *Virginia*, *Lederer*'s Discovery from *Virginia* to

the west of *Carolina*, the present State of *Virginia*, Accounts of the Discovery, and first Settlements in *New-England*, *New-York*, *Maryland*, *Pensilvania*, *Newfoundland*, Voyage to *Darien*, *Dampier*'s Voyages, *Ligon*'s History of *Barbados*, *Sloane*'s History of *Jamaica*, *Columbus*'s, *Frobisher*'s, Sir *Walter Raleigh*'s, *Cavendish*'s, *Hudson*'s, *Davis*'s, *Sparrey*'s, *Monk*'s Voyages. There are also many Voyages to the South Sea, as *Magellan*'s, *Sebald de Weert's*, *Spilbergen's* *Corneilson*'s, *Frezier*'s, *Cook*'s, *Wood*'s, &c.

Amicable *Numbers*, are such that are mutually equal to the Sum of one another's aliquot Parts, as are these Numbers 284, and 220. For all the aliquot Parts 1, 2, 4, 5, 10, 11, 20, 22, 44, 55, 110 of 220, are equal to all the aliquot Parts 1, 2, 4, 71, 142 of the Number 284. These two Numbers are also Amicable Numbers *viz.* 18416, and 17296. For the aliquot Parts 1, 2, 4, 8, 16, 23, 46, 47, 92, 94, 184, 188, 368, 376, 752, 1081, 2162, 4324, 8648 of 18416, are equal to the aliquot Parts 1, 2, 4, 8, 16, 1151, 2302, 4604, 9208 of 17296.

Van Schouten was the first who (I believe) gave this Name to such Numbers at *Sect.* 11. *Miscellan.* at the end of his *Exercitationes Geometr.* where he shews how to find them by common Algebra, bringing out the first Pair above mentioned, by supposing one of the Numbers to be $4x$, and the other $4yz$, and making an Equality between them and their several aliquot Parts, and bringing out the second Pair above mention'd, by supposing one of the Numbers to be $16x$, and the other $16yz$, and making an Equality between them and their aliquot Parts.

In the same Section he tells us, that *Descartes* gives the following Theorem relating to these Numbers. If you take the Number 2, or any other produced from the Multiplication of 2, provided it be such, that if 1 be taken from the Triple thereof, the remainder be a prime Number, and also if 1 be taken from 6 times the same, the remainder be a prime Number; I say, that if that Number be such, and this prime Number be multiplied by thrice the same, the Product will be one of the Amicable Numbers, and the other will be the Product of the first and second prime Numbers aforesaid, multiplied by the Square of the Number first taken.

It is easy to apprehend from the nature of these Numbers that there are but a very few of them, at least to be set down and manageable by us; for 284, and 220, are the two least; and the two next greater are 18416, and 17296. Those who are curious may find out the next Pair, for I neither know what they are, or have any Inclination to do it.

Ammunition. A Name for Powder and Ball, and other Implements of War. Cannon, Mortars, *&c.* are sometimes also called by this Name. The Quantity of Ammunition necessary for the Siege of a Place is shewn in the *Chevalier de Saint Julien*'s *Treatise de la Forge de Vulcain*, *p.* 126, *& seqq.* where he brings three Examples of his own, specifying particularly how much Ammunition was brought to the Sieges, and how much spent.

But the Quantity necessary to defend a Place, you will find in *Suirey de Saint Remy*'s *Memoires d'Artillerie*, *Part* 4. *p.* 292, *& seqq. Tom.* 1.

Amphiscii, Are the Inhabitants of the Torrid Zone, which are thus called, because the Shadow of the Sun at Noon, falls at one time

of

of the Year towards the North, and at the other, towards the South. And when the Parallel that the Sun moves in, is equal to the Latitude of the Place, and on the ſame ſide the Equator, the Moon's Shadow falls neither North nor South. See *Varenius*'s *Geogr. gener. Chap.* 27. *Prop.* 3.

Amphiprostile, in Architecture, is a ſort of a Temple of the Ancients, having four Columns in the Front, and the ſame Number in the hinder Face. *Vitruvius* gives the Deſcription, *C.* 1. *Lib.* 3.

Amphitheatre. A very large Building of the Ancients either round or ovalar, having a Pit, and a great number of riſing Seats within it, whereon the People uſed to ſit to ſee barbarous Shews, as the Combats of Gladiators, of wild Beaſts, &c. There were ſeveral of them, as the Amphitheatre of *Veſpaſian*, vulgarly called the *Coliſeum* at *Rome*, the Amphitheatre of *Flavius*, the Amphitheatre of *Statilus Taurus*, a Friend of *Auguſtus*'s at *Rome*, the Soldiers Amphitheatre at *Rome*, the Amphitheatre at *Verona*, and the Amphitheatre at *Niſmes* in *Languedoc* in *France*; the Remains of all which are ſtill to be ſeen. See *Deſgodetz* in his *Edifices Antiques de Rome. Overbeke's Reliquiæ antiquæ urbis Romæ. Montfaucon's Antiquities. Trattato degli Amfiteatri del Marcheſe Scipione Maffei. Fontana del Amfiteatri Flavio.*

Amplitude, is an Arch of the

Horizon, intercepted between the Eaſt or Weſt Point thereof, and the Centre of the Sun, or a Planet or Star at its riſing or ſetting. As let H R be the Horizon, A G the Equinoctial, O the true Eaſt or Weſt Point of the Horizon, and S the Centre of the Sun or a Star at its riſing or ſetting; then the Arch O S of the Horizon is the Amplitude, which is either ortive or occaſive, northern or ſouthern.

As the Coſine of Latitude : Radius : : Sine of the Sun's or Star's Declination : Sine of Amplitude. It is of uſe in Navigation, to find the Variation of the Compaſs. See more in *Wolfius*'s *Elemen. Aſtron.* §. 196. and his *Geogr.* §. 299. in the *Journal des Obſervations Phiſiques, Mathematiques & Botaniques*, made in *America* from the Year 1707 to 1712, by Father *Feuillée*, at the Command of the King of *France*. See alſo *Dechales*'s *Mundus Mathematicus, Lib.* 7. *de Navigatione. Tom.* 3. *Fol.* 335. & *ſeqq.*

Amplitude Magnetical, is an Arch of the Horizon contain'd between the Centre of the Sun at his riſing or ſetting, and the Eaſt or Weſt Point of the Compaſs. It is found by an Amplitude or azimuth Compaſs, by obſerving the Sun at his riſing or ſetting, and is always equal to the Difference between the true Amplitude, and the Variation of the Compaſs.

Anabibazon. The northern Node of the Moon is ſometimes ſo called.

Anacampticks. A Name given by the Ancients to that Part of Opticks which treats of Reflexion, being the ſame which we now call Catoptricks.

Anachronism. A Miſtake in Chronology.

Anaclaticks. An ancient Name for that Part of Opticks which treats of Refraction, being the ſame we now-a-days call Dioptricks.

tricks. See the *Compendium* of *Ambrosius Rhodius*, a mathematical Professor at *Wittenburg*, in *Lib.* 3. *Opticæ*, p. 384. & *seqq.*

Analemma. An astronomical Instrument, being a circular Plate either of Brass or Wood, containing a Projection of the Circles of the Sphere, from an Eye placed at an infinite Distance in that Diameter of the Sphere which passes thro' the East and West Points of the Horizon, wherein the Solstitial Colure, and all Circles parallel to it, will be concentrick Circles. All Circles oblique to the Eye will be Ellipses, and all Circles whose Planes pass thro' the Eye, will be right Lines. The use of this Instrument is to shew the common astronomical Problems, which it will do very easily, but not over and above exact, unless it be very large.

The Instrument is very ancient, being handled so long ago as by *Ptolemy* himself in a peculier Treatise, which was afterwards published with a Commentary upon it by *Frederick Commandine*. The best Treatise (at least of the Construction) of this Instrument, is in *Agulonius*'s *Opticks, Lib.* 6. See also *Taquet*'s *Optic. Lib.* 3. c. 7 f. 208 *Witty*, in his Treatise of the Sphere, c. 1. *Harris*'s *Lexicon*, under the Word *Analemma*, and *Dechales*, *Lib.* 2. *de Astrolabiis* f. 127, & *seqq. Tom.* 4. *Mundi Mathem.*

Analogy. The same as Proportion; which see.

Analysis. This properly is a Resolution of any thing into its component Principles, or taking its Parts all to pieces, in order to discover the thing. And in Mathematicks it is the Art of discovering the Truth or Falshood of a Proposition, or its Possibility and Impossibility, by supposing the Proposition such as it is, that is, true; and examining what follows from thence, until at length we come to some known or evident Truths, or some Impossibility, of which the first Proposition is a necessary Consequence, thereby to conclude the Truth or Impossibility of that Proposition, which may afterwards be demonstrated by Composition, from the Re assumption of the Reasonings whereby it was performed and finished.

The Analysis of the ancient Geometricians, which may be called *Geometrical Analysis*, consisted in a judicious Application of the Propositions of several Books, (such as *Euclid*'s *Data*, *Apollonius de Sectione Rationis*, *de Sectione Spatii*, *de Tactionibus*, *de Inclinationibus*, *de Locis Planis*, *de Sectionibus Conicis*. *Aristeus de Locis Solidis*. *Euclid de Locis ad Superficiem*, *Eratosthenes de Medietatibus*; Euclid's *Porisms*; and other Books, to the Number of 31, (as we learn from *Lib.* 7. of *Pappus*'s *Collectiones Mathematicæ*) proceeding Step by Step from one known Truth to another, till they arrived at last to that required. Examples of which may be seen at Prop. 107, 117, 155, 204, 205, of the said 7th Book of *Pappus*. The Ingenious *Hugo d'Omerique* too, in his *Analysis Geometrica*, has endeavoured to restore this Analysis of the Ancients; where he has set an Example worthy the Imitation of all those who have at heart the true and genuine Way of solving Geometrical Problems, tho' it must be confess'd, that *Algebra*, which may be called an *Arithmetical Analysis*, is the most ready, and general Method, (but not always the shortest and most elegant) that has been hitherto found out, or perhaps ever will, for this Purpose.

Analysis *of Infinites*, the same with Fluxions; which see.

Analysis *of Powers*. The extraction of Roots, or Resolution of Powers.

Analysis *of Situation*. A Bragadocio

gadocio Term of *Wolfius* in his *Elem. Mathem.* attributed to Mr. *Leibnitz*, where he says that this latter would give the Solutions of Problems by it after a manner quite different from what has been hitherto known or thought of. But alas! the Dream has not been yet discovered to the Publick.

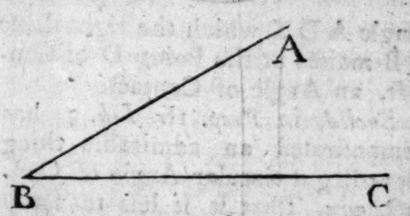
ANDROMEDA. A small northern Constellation, consisting of 27 Stars visible to the naked Eye, behind *Pegasus*, *Cassiopeia*, and *Perseus*. She represents a Woman chained to a Rock. The Poets have many Fictions concerning her. She is called *Mulier Catenata*, *Persea*, *Virgo Devota*, and by some *Vitulus Marinus Catenatus*. *Shiller* makes her the holy Sepulchre. *Harsdorff*, will have her to be *Abigail*, 1 *Sam.* xxx. 5. and *Weigel* changes her into the Arms of *Heidelburgh*.

ANEMOMETER. An Instrument to measure the force of the Wind, invented by *Wolfius* in the Year 1708, and first published by him, *Anno* 1709, in his *Areometry*. As also in the *Acta Eruditorum* for 1709, and in the *Areometry* belonging to his *Elem. Matheseos*: And in his *Mathematical Dictionary*. He says, he tried the goodness thereof; and tells you that the inward Structure thereof may be preserved, even to measure the Force of running Water, or that of Men and Horses when they draw.

ANEMOSCOPE. An Instrument shewing at any time which way the Wind blows, that is, from which of the 32 Points of the Compass it comes, by means of an Hand or Index moving about an upright Circular Plate; which Index is turn'd about by an Horizontal Axis, which Horizontal Axis is turned about by an upright Staff, at the top of which is the Fane, moved about by the Wind. These are very common about *London*, as at *Buckingham*-House, *St. James's*, my Lord *Godolphin's*, &c. See a more particular Description by *Vitruvius*, *Casatus* in his *Mechanicks*, *Lib.* 5. *Cap.* 9. and *Ozanam* in his *Mathem. Dictionary*.

Wolfius, in his *Mathem. Lexicon*, speaks of an Anemoscope, consisting of a little wooden Man, which by its rising and falling in a Glass Tube, shews the Change of the Weather, and the Alteration in the Gravity of the Air, which was the Invention of *Otto Guerick*, who mentions it in *Lib.* 3. *Experimentorum Magdeburg.* c. 20. f. 100. But makes a Secret of it, which he would not discover. But at length Mr. *Comiers* Professor of *Mathem.* at *Ambrun*, has discovered it in the *Acta Eruditorum*, *Anno.* 1684. p. 26, *& seqq.* where he would have the Homunculus to be moved up and down by the rising and falling of the Mercury in the *Barometer*.

ANGLE, is the Inclination of two Lines meeting one another. As let the Line A B, meet the Line



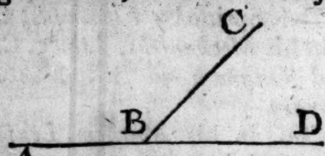
C B in the Point B: Then is their Inclination or bending towards each other, an Angle.

Angles are of vast use, not only in Geometry, but almost in all other Parts of Mathematicks. The nature of Figures cannot be explained without them. They are half the Subject of Trigonometry, and have much to do in Geography and Astronomy.

ANGLE ACUTE, is the Angle A B C, being less than a right Angle.

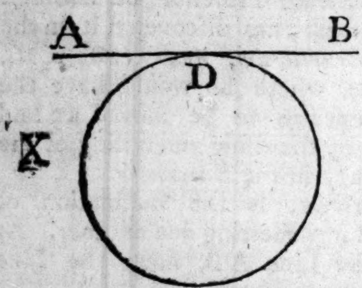
ANGLES ADJACENT, are such that have the same Vertex, and one common

common Side continued out, as the Angles A B C, C B D are Adjacent



Angles, and both taken together, are always equal to two right Angles, (13. 1. *Eucl.*) And if the one be acute, the other will be obtuse, and contrariwise.

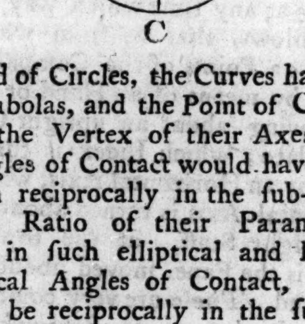
ANGLE *of Contact*, is the Angle which a right Line that touches a Curve Line makes with it. As let the right Line A B, touch the Circle X in the Point D: Then is the



Angle A D X which the right Line A B makes at the Point D of Contact, an Angle of Contact.

Euclid, in *Prop.* 16. *Lib.* 3. has demonstrated an admirable thing regarding a circular Angle of Contact, *viz.* That it is less than any given right-lin'd Angle. And this has given rise to many Disputes amongst the Geometricians about how it should happen, and to many surprizing Paradoxes. To account for which, they have involved themselves into much Absurdity and Error. The good old *Clavius*, and *Peletarius*, a Professor of Mathematicks in *France*, had a long Dispute about it, as you may see in *Lib.* 3. of his *Euclid*, where the former asserts, and indeed rightly too, that an Angle of Contact, is of a different kind from a right lin'd Angle, having the same regard to it, as a Line to a Superficies, or a Superficies to a Solid; and that because if it be never so often multiplied, it will never be equal to, or exceed any the least right-lin'd Angle. But Dr. *Wallis*, in a Discourse of the Angle of Contact, published in his Arithmetick of *Infinites*, does wrongly (as I think) with *Peletarius*, say it is no Angle at all. *Taquet*, in his *Euclid* too, at *Schol. Prop.* 16. *Lib.* 3. (where he gives us Paradoxes about the Angle of Contact) will not have any Angle whatsoever to be a Quantity. But a Mode or Quality only, and so according to him the Comparison of Angles is not as to Equality and Inequality, but Likeness and Unlikeness. But alas this is a mere Fetch to answer his Purpose: A false Strain to account for his Difficulties.

Angles of Contact are true Angles, and may be compared to one another, tho' they cannot to right-lin'd Angles; they being infinitely smaller than these; for the circular Angles A D F, A D G, of Contact, are to each other in the reciprocal sub-duplicate Ratio of the Diameters D C, D E. And if in-

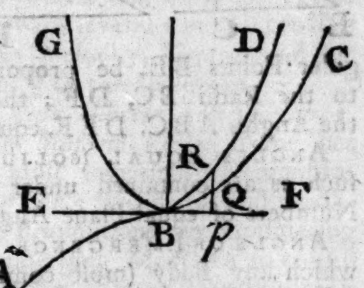


stead of Circles, the Curves had been Parabolas, and the Point of Contact D, the Vertex of their Axes; the Angles of Contact would have been then reciprocally in the sub-duplicate Ratio of their Parameters. But in such elliptical and hyperbolical Angles of Contact, these will be reciprocally in the sub-duplicate Ratio of the Ratio compounded

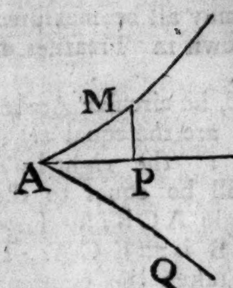
pounded of the Ratios of the Parameters, and transverse Axes.

Hence a circular Angle of Contact may be divided into any Number of equal Parts by circular Arches, or into any given Ratio.

If G B D be a common Parabola, and E F a Tangent to the Vertex at B, and A B C be a cubical Parabola, which E F touches in B, that is, if the Abscis B P be called x, and the rectangular Ordinates P Q, P R, be called y; if $1 \times y$ be $= x x$, in the



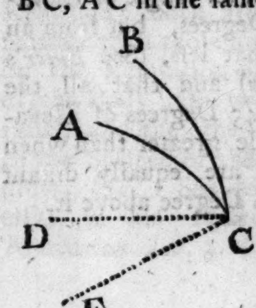
common Parabola, and $1 \times y = x^3$ in the cubick one, and if other parabolical Curves were described to the Abscis or Tangent E F, being such that $y=x^4$, $y=x^5$, $y=x^6$, &c. then will the parabolical Angle of Contact R B P be infinitely greater than the cubical parabolical Angle of Contact Q B P, and this here Angle of Contact infinitely greater than that of the Curve, whose Equation is $y=x^4$, and that of this latter Curve infinitely greater than that of the Curve, whose Equation is $y=x^5$, and so on *ad infinitum*. And moreover, between the Angles of Contact of any two of this kind, may other Angles of Contact be found *ad infinitum*, that will infinitely exceed each other, and yet the greatest of them are infinitely less than any the least right-lin'd Angle; so also $y^2=x^3$, $y^3=x^4$, $y^4=x^5$, &c. denote a Series of Curves, of which every succeeding one makes an Angle with its Abscis, infinitely greater than the preceding one, where it may be observed that the Angle of Contact M A P, at the Cusp A



the semi-cubical Parabola M A Q expressed by the Equation $yy=x^3$, is infinitely greater than any circular Angle of Contact which is of the same kind with a parabolical one.

This wonderful and almost incomprehensible Doctrine, was first advanced by Sir *Isaac Newton*, in *Schol. Lem.* 2. at the beginning of *Lib.* 1. *Princip. Mathem.* as also in his Treatise of Fluxions; but without any sort of Proof or Demonstration. The whole I believe depends upon these two things, that those Angles of Contact are infinitely greater than others, when any one evanescent or infinitely small Substance of the former, is infinitely greater than any one of the latter. And when x the Abscis of any Curve becomes infinitely small, x, x^2, x^3, x^4, &c. and $x^{\frac{1}{2}}$, $x^{\frac{3}{2}}$, $x^{\frac{5}{2}}$, &c. will be a Series of Quantities decreasing, whereof any one of the former, will be infinitely greater than that next following it. And x, $x^{\frac{1}{2}}$, $x^{\frac{1}{3}}$, $x^{\frac{1}{4}}$, &c. $x^{\frac{3}{2}}$, $x^{\frac{4}{3}}$, $x^{\frac{5}{4}}$, &c. will be a Series increasing in the same manner.

Angle Curv'd Line, is the mutual Inclination of two Curve Lines, meeting in one Point, in the same Plane, as the Angle A C B contain'd under the two Curves B C, A C in the same Plane meeting in the Point C, is a Curvelin'd Angle.



Under this Denomination are contain'd the Curv'd-line Angles, made upon a Plane from the stereographical

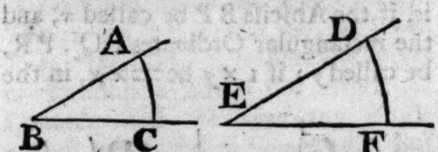
cal Projection of the Circles of the Sphere, which may all be measured by Rules laid down in Treatises of that Projection.

If A C, B C, be circular Arches whose Radius's are the equal right Lines D C. E C; the right-lin'd Angle D C E will be equal to the curv'd Line Angle A C B; for since the Angle D C B is = E C A. If from each be taken the common Angle D C E, there will remain the right Line Angle D C E, equal to the curv'd Line Angle A C B.

Angle of Elevation, in Mechanicks, is the Angle which the Line of Direction of a Body (usually a Ball) projected with any force, makes with an Horizontal Line. *Gallileus*, in his *Dialogues of Motion*, was the first who has shewn that this Angle must be 45 Degrees, to cause the projected Body to go to the greatest Distance or Range possible, with the same force, and that at Elevations as much above 45 Degrees, as under it, will fly to the same Distance. And on the contrary, when the Line of Direction is parallel to the Horizon, the Range will be the shortest possible. This is demonstrated by Dr. *Keil*, in his *Introduction to true Philosophy*; by Mr. *Cotes*, in his *Harmon. Mensurarum*; by *Wolfius*, in his *Mechanicks*, and many other Authors. But it is grounded upon a Supposition, that the Projectile suffers no Resistance from the Air it moves thro', which it really does; and this causes the farthest horizontal Range not to happen from an Angle of Elevation of 45 Degrees, but from an Angle somewhat less, (See *Euler*'s Book *de Motu*) and that all the Ranges under 45 Degrees of Elevation, are a little greater than when the Elevation are equally distant from the 45th Degree above it.

Angles Contiguous. See *Angles adjacent*.

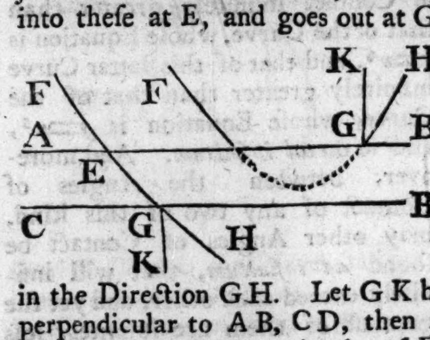
Angles Equal are such (right-lin'd ones) where the Arches of Circles described from the angular Points, and intercepted between the Sides, are proportional to their respective Radius's: As let the Arches A C, F D of Circles described from the Centres or an-



gular Points B E, be proportional to the Radii B C, D F; then are the Angles A B C, D E F, equal.

Angles Equal (solid,) are such as are contained under equal Numbers of equal Plane Angles.

Angle of Emergence. That which any Body (most commonly a Ray of Light) projected from one Fluid or Medium (as Air) into another, makes at its going out of the latter Fluid or Medium (as Water or Glass, whose Surfaces are parallel Planes,) with a Perpendicular to those Planes; as let A B, C B be parallel Planes bounding Water or Glass, and supposing a Body projected in the Direction F E, entering into these at E, and goes out at G,



in the Direction G H. Let G K be perpendicular to A B, C D, then is the Angle K G H an Angle of Emergence.

The Sine of the Angle of Emergence, when the projected Body passes

passes quite thro' the Medium, is to that of Incidence, in a constant Ratio. But when the projected Body flies back or out of the Medium, the same way it came in, without passing quite thro'; the Angle of Emergence, will always be equal to the Angle of Incidence, which is the case of Cannon Balls, shot obliquely into the Water, or even light Earth, or flattish Stones that Boys throw into the Water to make Ducks and Drakes, as they say: All of which will come out again, and perhaps several times, according to their Velocity, Figure, and the Obliquity of the Incidence.

Sir Isaac Newton, Sect 14. *Lib.* 1. *Princip. Mathem. Philos. Natur.* has given most ingenious Demonstrations of these two useful and fundamental Propositions, by considering the immerging Mediums to consist of Particles that uniformly attract the immerged Body in its Passage, and from thence concludes the Line E G, thro' which it passes, to be a Parabola; and then shews how the first Proposition follows from the Nature of the Parabola. And as to the second, he gathers that from a Proposition founded upon the first, *viz.* That the Velocity of the Body before the Incidence, is to that after it is emerged, as the Sine of the Angle of Emergence is to that of Incidence; and from this he deduces the said Proposition, together with the following one; that the Motion before the Emergency, must be greater than that after it, to cause the Body to be reflected.

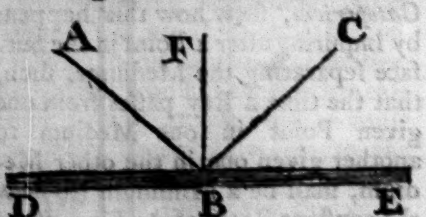
Hence the famous catoptrical Proposition, that the Angle of Incidence is equal to the Angle of Reflexion, follows as a Corollary, *viz.* by supposing the Depth or Way of the Emergence to become infinitely small, or the Body to be reflected at the Point of Incidence, without entering at all into the Medium.

The two Propositions aforesaid, are investigated or proved after other ways by Authors; particularly Dr. *Barrow*, in his *Lectiones Opticæ*, deduces them from a very remote Consideration, where he would have a Ray of Light to be of a cylindrical-Figure, or rather right-angled Parallelogram, and to revolve about upon its coming to touch the Surface separating the Mediums. See *Lect.* 2. Others, as Mr. *Jones* in his *Synopsis Palmariorum*, and *Wolfius*, in his *Dioptricks* and *Catoptricks*, shew how this happens by inquiring after a Point in the Surface separating the Mediums, such, that the time a Ray passes from one given Point in one Medium to another given one in the other Medium, shall be a Minimum (to shew the constant Ratio of the Sines of the Angles of Emergence and Incidence) and that the Aggregate of the Lines drawn from one given Point in the upper Medium to another in the same, shall be a Minimum (to shew the equality of the Angles of Reflexion and Incidence.) See in *Wolfius* §. 35. *Diop.* and 24 *Catop.* See also Dr. *Gregory*'s *Opticks*, &c.

Sir *Isaac Newton*, in his *Opticks*, *Prop.* 6. *Part* 1. has shewn the truth of the constant Ratio of the Sines of the Angles of Incidence and Emergence; and Dr. *Keil*, in his *Vera Physica* the truth of the Equality of the Angles of Incidence and Reflexion; both after a different manner than those hinted at before, by the Resolution of the Motion of the Body into two, the one parallel, and the other perpendicular to the Surface of the Fluid or Medium, &c. See Mr. *Gravesande* also, in his *Institutiones Philos. Newtonian. Lib.* 3. *Part* 2. c. 6.

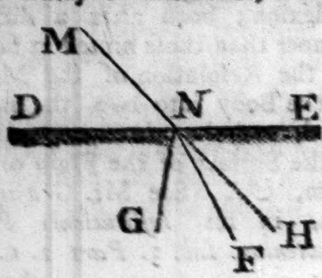
ANGLE OF INCIDENCE, is that which the Line of Direction of a striking Body (as a Ray of Light, &c.) makes at the Point where it first touches or comes at the Body it strikes against, with the Perpendicular to the Surface of the Body it strikes against.

ANGLE OF REFLEXION, is that which is made by the Line of direction of a Body rebounding after it has struck against another Body, at the Point of Contact, from whence with a Perpendicular at that Point of Contact it rebounded: as let a Body moving in the Direction AB, strike against the Surface DE in the



Point B, and by that means be reflected or driven back again in the Direction BC, and let BF be perpendicular to DE; then is ABF the Angle of *Incidence*, and FBC the Angle of *Reflexion*; and upon the Equality of these two Angles, the whole Science of Catoptricks is entirely founded.

ANGLE OF REFRACTION, in Dioptricks, is the Angle which a Ray of Light refracted makes with a Ray of Incidence, continued out beyond the refracting Superficies. As let DE be the refracting Superficies, MN a Ray of Incidence, and NF



that Ray refracted. Also let NH be the Continuation of the Ray of Incidence, then is FNH the Angle of Refraction.

ANGLE REFRACTED, is the Angle which a refracted Ray makes with a Perpendicular to the refracting Surface; as let GN be perpendicular to the refracting Surface DE, then is GNF the refracted Angle.

1. The Ratio of the Sine of the Angle of Incidence to the Sine of the refracted Angle, is found to be invariable. If the Refraction be from Air into Glass, it will be greater than 114 to 76, but less than 115 to 76; that is, nearly as 3 to 2, as Mr. *Huygens* has shewn in his *Dioptricks*, p. 5. Sir *Isaac Newton* too, in his *Opticks, Part* 3. *Lib.* 2. agrees with Mr. *Huygens*, *viz.* That the Ratio of the Sine of the Angle of Incidence, is to that of the refracted Angle as 31 to 20, that is, nearly as 3 to 2, which is a very proper Ratio to explain the Refraction in Glass Lens's.

2. *Descartes in Tract. de Meteoris*, C. 8. §. 10. p. m. 222. found that in Rain Water the Ratio abovesaid was as 250 to 187, or nearly as 4 to 3; to whom Sir *Isaac Newton*, in his *Opticks*, agrees; where he says, it is as 529 to 396, but in Spirit of Wine he makes it as 100 to 73.

3. If one Angle of Incidence be given, and the correspondent refracted Angles be observ'd by Experiment, it will be easy to compute the refracted Angles answering to every Angle of Incidence. *Kircher* (*in Arte Magna Lucis et Umbræ, Lib.* 8. *Part* 1. c. 2) and *Zahan* (*in Oculo Artific. Fund.* 2. *Syn.* 1. c. 2. f. 228, *& seq.*) say, when the Angle of Incidence is 70°, they found the refracted Angle to be 38° 50′.

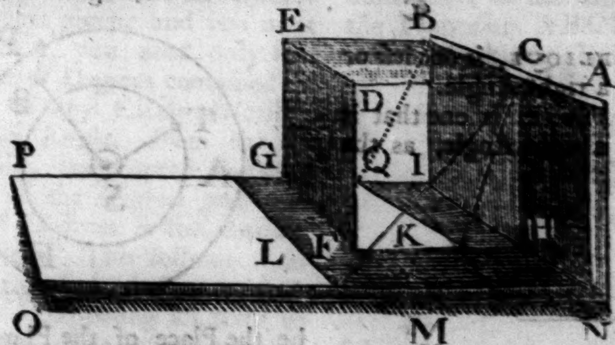
When a Ray moves out of Air into Glass, or out of a rare Medium

into

into a denser one, the refracted Angle is always less than the Angle of Incidence; and when the Angle of Incidence is nothing, the refracted Angle will be so too.

5. If the Angle of Incidence be less than 20°, and a Ray moves out of Air into Glass, the refracted Angle will be nearly one third Part of the Angle of Incidence, and this is the Principle that *Kepler*, and after him most other Writers of Opticks have used to explain the Refractions in Glass; for imitating *Alhazen*, and *Vitellio*, they sought after the Law of Refraction in the Ratio of the Angles, and so could not arrive at the precise Truth.

6. There are several ways of observing the Quantity or Law of Refraction (to be found here and there in Authors) whereof the following one is easy; suppose it be from Air to Glass, being that which is mostly wanted in Dioptricks. Let FGBC be a well polished Glass Cube, standing upon a Plane Board NIPO; at the end of which there is another NABI fix'd at right Angles, having the same height CH with the side of the Cube, and suppose their common breadth IN, to be greater than the side IH of the Cube, and the length

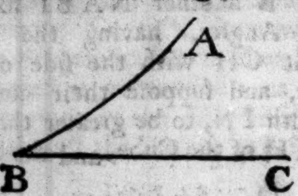


ON, to be much longer than either; then when these Boards and the Cube upon them close to the upright one, be turned to the Sun at different Latitudes above the Horizon, note the end of the Shadow of the side AB, both within the Cube at K and without it at L; then since CK is the refracted Ray, and CL the unrefracted one, HCK will be the refracted Angle, and HCL the Angle of Incidence; so that if CL be the Radius, HL will be the Sine of the Angle of Incidence, and HK that of the refracted Angle; so that if HK and HL be carefully measured by an exact Scale of equal Parts, you will have in Numbers the Ratio of the Sine of the Angle of Incidence, to that of the refracted Angle, and if instead of a Cube of Glass, you use a little Vessel of Water or other Liquors, you may observe the Law of Refraction in Water or other Liquors.

7. The first Invention of this famous Dioptrick Theorem of the constant Ratio of the Sines of the Angles of Incidence and refracted Angles, upon which the whole Science depends, is commonly attributed to *Descartes*, (see his *Dioptr.* c. 2. §. 2. p. m. 57.) tho' it was well known to *Willebrord Snell*. (See *Huygens*'s *Dioptr.* p. 2. and 3.) And *Vossius de Natura & Propri. Lucis*, p. 36. published *anno* 1642, wherein this last says it appears from *Snell*'s Papers, which he himself had seen, that *Snell* had found out that the Proportion between the Secants of the Angles, which are the Complements of the Angle of Incidence, and

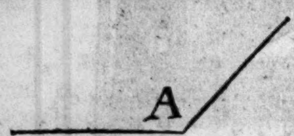
and the refracted Angle to right ones is constantly the same. *Kepler* also was very near finding out this Theorem, who at *Prop.* 5, 6. in his *Tract.* called *Paralipom. in Vitellionem*, lays down these Secants for the respective Measure of Refractions.

Angle mixt-lin'd, is that contain'd under a right Line and a curve Line, as the Angle A B C.

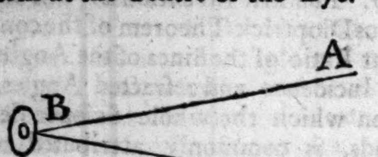


Angle oblique, is one less or greater than a right Angle.

Angle obtuse, is one that is greater than a right Angle, as the Angle A.

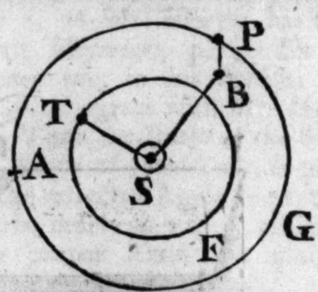


Angle optick or of Vision, is the Angle A B C, which two Rays A B, C B, issuing from the extreme Points A, C of an Object, form at the Centre of the Eye.



The apparent Magnitude of an Object is measured by this Angle. Those things which are seen under a greater Angle, appear to be greater, and those under a lesser, to be less; and those under an equal one, to be equal. This same Angle is also used in Opticks, to shew how one Object under given Circumstances, appears equal, bigger or lesser than others, as may be seen in optical Writers; among which, see *Wolfius Cap.* 5. *Elem. Optic.* The ancient *Opticians*, as *Euclid*, *Ptolemy*, *Alhazen* and *Vitellio*, formerly used these Angles to explain how one Thing or Object appears great or small.

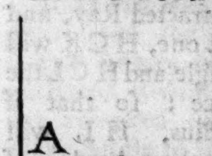
Angle of Communication, in Astronomy, is the difference between the true Place of the Sun, seen from the Earth, and the Place of the Planet, when reduced to the Ecliptick; as let T F be the Orbit of the Earth, T A P G the Orbit of a Planet P, and S the Sun; let B



be the Place of the Planet reduced to the Ecliptick; then is the Angle T S B the Angle of Commutation.

As the Sine of the Angle of Commutation, to the Sine of the Angle of Elongation, so is the Tangent of the heliocentrick Latitude of a Planet to that of its geocentrick Latitude.

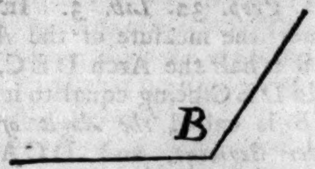
Angle right, is that which is made by two right Lines perpendicular to each other, as the Angle A. This always is equal to that contiguous to it, and the measure thereof is 90 Degrees.



Angle Plane, is the mutual Inclination of two Lines in a Plane, meeting in one Point.

Angle right-Line, is that made by two right Lines meeting in

in one Point, *viz.* whose Sides are right Lines, as the Angle B.



1. The Quantity of a right-lin'd Angle, is not measured by the length of its Sides, it being no ways proportional to them, but by the Arch of a Circle described within the Angle, intercepted between the Legs of the Angle, whose Centre is the angular Point; that is, if there be an Angle given, and you want to measure it, you need only find the number of Degrees contained in the Arch of any Circle described within the Angle, from the angular Point, intercepted between the sides of the Angle; and that number of Degrees is the measure of the Angle. This follows from *Prop.* 33. *Lib.* 6. and *Prop.* 1. *Lib.* 12. *Euclid.* (supposing a Circle to be a Polygon of an infinite number of Sides.)

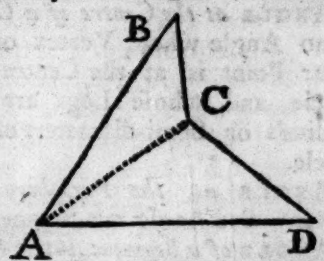
The Doctrine of right-lin'd Angles, is of great use, as well in the Theory as Practice of Geometry, because they are principal parts of all right-lin'd Figures.

2. No Angle can have for its Measure quite 180 Degrees, for in this Case one side will fall into the same right Line with the other, that is, they will be both one right Line, and so cannot form an Angle, they having no Inclination. And from hence there seems to arise an odd Paradox, *viz.* That the Aggregate or Sum of several Angles shall be no Angle at all.

3. The Sum of all the Angles that can be made at the same Point, consists of 4 right Angles, whose Measure is 360 Degrees.

4. The Sum of all the internal or inward Angles of any right-lin'd Figure, is equal to twice as many right Angles, excepting 4, as the Figure has sides; this follows from *Prop.* 32. *Lib.* 1. *Euclid.* and the Sum of all the external Angles, which are the Angles without the Figure, when all the Sides are severally produced, make 4 right Angles; this follows also from *Prop.* 13. and 32. *Lib.* 1. *Euclid.* See *Clavius*, *Barrow*, and other Expounders of *Euclid.*

But here we ought to observe, that when a right-lin'd Figure has one or more Angles which open outwardly, as the Angle B C D of the Trapezium A B C D; what is meant by this Angle in the Propo-

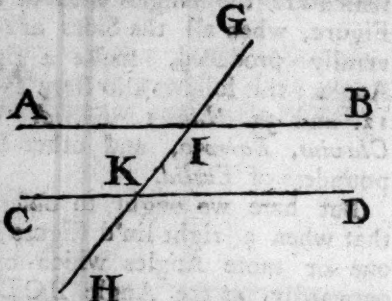


sition, is the sum of the Angles A C B, A C D made by drawing the Line A C from the opposite Angle B A D: for if otherwise, you would understand the Angle B C D, which according to the Definition of an Angle, must be one Angle of the Figure, the Proposition is false.

5. Angles in practical Geometry, are measured upon Paper with a Line of Chords, or Protractor, and upon Ground or at Sea with a Theodolite, Circumferenter, Quadrant, Cross Staff, &c. as may be seen in the uses of the several Instruments.

6. A given Angle may be multiplied any number of times geometrically; but on the contrary, you cannot divide one geometrically into any number of equal Parts. But the Cycolid will assist us in doing this thing universally.

Angles Alternate. These are the Pairs of acute or obtuse Angles made by a right Line cutting two parallel right Lines, being always equal to one another. Thus if A B be parallel to C D, and the Line G H cuts them in I and K,

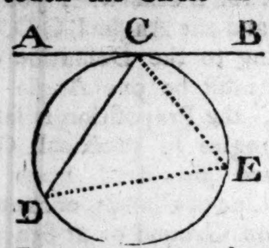


then are the Angles A I K, D K I, and B I K, I K C alternate Angles.

Angle *at the Centre of a Circle*, is an Angle whose Vertex or angular Point is at the Centre of a Circle, and whose Legs are two Radius's or Semi-diameters of that Circle.

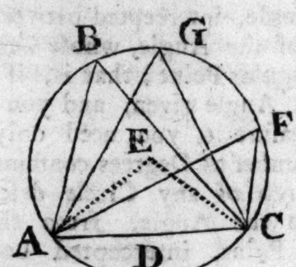
Angle *at the Periphery of a Circle*. See Angle in a Segment.

Angle *of a Segment*, is the Angle which a chord Line in a Circle makes with a Tangent at the Point of Contact: As let the right Line A B touch the Circle in C, then

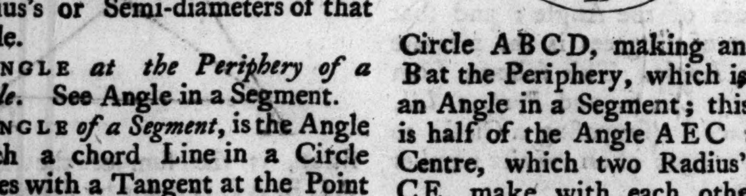


if a Chord D C be drawn, the Angle A C D is an Angle of a Segment; the measure of this Angle is half the Arch C D, being equal to the Angle D E C, as *Euclid* has shewn, *Prop.* 32. *Lib.* 3. In like manner the measure of the Angle D C B is half the Arch D E C, the Angle D E C being equal to it; but D C B is called *the Angle of the greater Segment*, and D C A *the Angle of the lesser Segment*.

Angle *in a Segment*, is that which two Chords of a Circle make with each other at its Periphery. A B, C B are two Chords of the



Circle A B C D, making an Angle B at the Periphery, which is called an Angle in a Segment; this Angle is half of the Angle A E C at the Centre, which two Radius's A E, C E, make with each other, and has for its measure half the Arch A D C, upon which it stands, as you will find in *Prop.* 30. *Lib.* 3, *Euclid*. Moreover, all Angles A B C, A G C, A F C in a Segment, or which stand upon the same Arch A C B, are equal to one another. When the Arch A B C (Fig. 1.) is a Semi-circle, A B C will be a right Angle. When it is (Fig. 2.) greater than a Semicircle, the said Angle will be acute. When it is (Fig. 3.)



less, that Angle will be obtuse. *Euclid* has demonstrated these at *Prop.* 31, 32. *Lib.* 3. The Angle ABC (in Fig. 1.) is called an *Angle in a Semi-circle*. That (in Fig. 2.) an *Angle in a greater Segment*; and that (in Fig. 3.) an *Angle in a lesser Segment*.

ANGLE *of a Semi-circle*, is the Angle which the Diameter of a Circle makes with the Circumference, concerning which *Euclid*, (*Prop.* 16. *Lib.* 3.) and others have given the following Paradox, *viz.* That it is less than a right Angle, and at the same time greater than any acute right-lin'd Angle. This is amongst the Disputes about the Angle of Contact; but neither it nor its Paradoxes are of any great use.

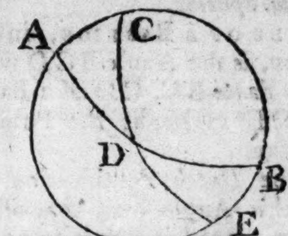
ANGLE *in a Semi-circle*, is an Angle in a Segment, whose Base is the Diameter of that Circle. See Fig. 1. under *Angle in a Segment*.

ANGLE SOLID, is the meeting of three or more Lines, not all in the same Plane, in one Point; or it is an Angle contained under more than two Plane Angles, not being in the same Plane, and meeting in a Point. For Example, in a Room where the two Walls and the Ceiling meet, there a solid Angle is formed, by these Lines, which are the perpendicular common Sections of the Walls, and the two common Sections of the Walls and Ceiling, all meeting in one Point.

Euclid has shewn, (*Prop.* 20, 21. *Lib.* 11.) That if a solid Angle be contain'd under three Plane Angles, any two of them howsoever taken are greater than the third; and that every solid Angle is contained under less Angles than four plane Angles; so that the sum of all the plane Angles, of which any solid Angle consists is less than 360 Degrees.

Solid Angles are equal, when they are contained under plane Angles, equal both in Magnitude and Multitude; and their Nature must be known, in order to shew that there can be but five regular Bodies.

ANGLE SPHERICAL, is an Angle formed on the Surface of the Sphere, by the Intersection of the two greater Circles; or rather, it is the Inclination of the Planes of the two great Circles of the Sphere: As let ACBE be a Sphere, upon the Surface of which let two Arches

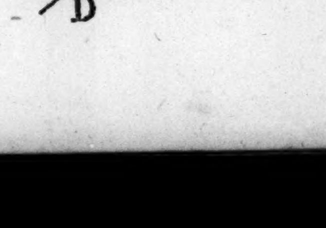


of great Circles AB and CE cut one another in D; then is ADC or DBE a spherical Angle.

The measure of a spherical Angle ADC, is the Arch of a great Circle AC, described from the Vertex D, as its Pole contain'd between the Legs AD, CD; or it is the distance of the Poles of the two Circles AB, CE. This follows, because the measure of a spherical Angle is the same as the Inclination of the Planes of the great Circles forming it, and the measure of the Quantity of the Inclination is the Arch AC; and from the Definition of the Pole of a great Circle.

All spherical Angles described about the same Point, are equal to four right Angles.

ANGLES VERTICAL, are each opposite Pair of those made by two Lines cutting or crossing each other; as let the right Lines AB, CD cut



each

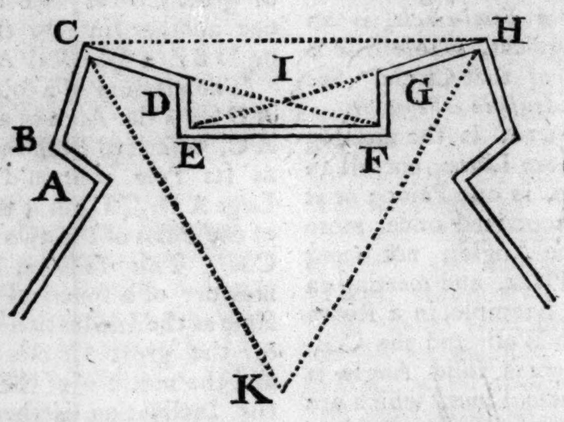
each other in the Point E; then are the Angles AEC, DEB, and CEB, AED vertical Angles.

When two right Lines or two great Circles of the Sphere cut each other, the vertical Angles are equal. The first is shewn by *Euclid, Prop.* 15. *Lib.* 1. and the other in most Treatises of *spherical* Trigonometry; amongst which *see Wolfius* §. 33. *Elem. Spheric.*

ANGLE OF A BASTION, in Fortification, is the Angle BCD which the two Faces BC, CD of a Bastion ABCDE make at the Point of the Bastion.

In the *Dutch* Fortification they make this Angle $\frac{2}{3}$ of that of the Polygon, until it comes to 90 Degrees, which Magnitude they will not exceed, as may be seen in *Freytag's Fortification*; all the Moderns make it above 100 Degrees. See *Wolfius's Elem. Architect. Milit. cap.* 2. *Nouvelle Maniere de Fortifier les Places*, p. 25. *Sturmy* too, in his *Veritable Vauban*, p. 150, 151. makes it obtuse; and all *Ingeniers* agree, that this Angle must not be less than 60 Degrees, tho' Mr. *de Ville*, in his *Fortification*, says 90 Degrees is the best bigness for this Angle. See his Reasons. Some call this Angle a *Flank'd Angle*.

ANGLE *of or at the Centre*, (in Fortification) is the Angle CKH, drawn from two Angles C, H, (nearest to each other) to the Centre



K of a regular Figure. These are found by dividing 360 Degrees by the number of Sides that the Figure has.

ANGLE *of a Polygon*, is the Angle which one Side of a Polygon makes with the other. In regular Figures the Quantity of this Angle is $180^\circ - \frac{360^\circ}{n}$ if n be the number of Sides.

ANGLE *of the Tenaille*, is the Angle CIH made before the Courtain by the two Lines of Defence CF, and EH.

ANGLE FLANKING, is the Angle CFG made by the Line of Defence CF and the Flank FG of a Bastion.

In the ancient *Fortification*, this Angle is acute, as may be seen in *Freytag's Book*, and then the Angle EFG was a right Angle. *Blondell* makes it obtuse; but on the contrary *De Grave* from *Pagan*, with most of the Moderns, a right Angle; which is look'd upon as more reasonable. See *Wolfius's Elem. Archit. Milit.* §. 64. Because in this case the Face GH of the Bastion has a stronger and better Defence.

ANGLE *re-entring or re-entrant*, by the *French*, is any Angle in Fortification

tification whose Point turns inwards towards the Place; that is, those Legs open outwards towards the Field. It is not easy to be fortified, as may be seen in the Writers of *irregular Fortification*, where it is particularly handled; amongst which, see *Wolfius*'s *Archit. Milit.* §. 187.

ANGLE SORTANT, or SALIANT, by the *French* (in Fortification,) is any Angle whose Point turns outwards, (such as those of Bastions, &c.) that is, whose Legs open inwards towards the Place.

ANGUINEAL HYPERBOLA. A Name given by Sir *Isaac Newton* to four of his Curves of the second Order, *viz.* Species 33, 34, 35, and 36. expressed by the Equation $xyy.\ ey = -ax^3.\ bx^2.\ cx.\ d.$ being Hyperbola's of a serpentine Figure.

ANGULAR. Any thing belonging to, or which has Angles.

ANGULAR MOTION, *in Astronomy*, is the increasing or decreasing Angle made by two Lines drawn from a central Body, (as the Sun or Earth) to the apparent places of two Planets in motion.

The angular Motions of a Planet and the Earth at the Sun made in the same time, are reciprocally proportional to their periodical Times.

ANIMATED NEEDLE. Some call a Needle touched with a Loadstone by this name. See *Compass*.

ANNUAL EQUATION. See *Equation*.

ANNUITY. A name for any yearly Income, arising from Money lent, Houses, Lands, Salaries, Pensions, &c. being divided into two sorts, *viz.* for a Term of Years, or upon a Life.

1. If the Amount of Annuities in Arrear at simple Interest be wanted, and a be the Annuity, r the rate of 1 Pound per annum, m the Amount thereof, and n the number of years; then if $a, n, r,$ are given, m will be $= na + \frac{\overline{nn - n}}{2} \times ar$, So that when any three of these four Quantities m, n, a, r, are given; it is very easy to find the Value of the fourth. But if it be compound Interest, and x $(= 1 + r)$ be equal to the Principal and Interest of 1 Pound, at any given rate; then will

$$m \text{ be} = \frac{\overline{x^n - 1} \times a}{x - 1};$$

$$a = \frac{\overline{x - 1} \times m}{x^n - 1}$$

$$n = \frac{L, \overline{x - 1} \times \overline{m + a} - L, a}{L, x};$$

$$x = -x^n + \frac{m}{a} x = \frac{m - a}{a}.$$

L being the Logarithm of $x - 1$ and of a.

2. If the Discount, &c. in buying and selling of *Annuities*, &c. at simple Interest be wanted, let $\frac{na + \frac{1}{2}\overline{nn - n} \times ar}{1 + nr}$ be $= s$, then

$$\text{will } a \text{ be} = \frac{2 + 2nr \times s}{2 + nr - r \times n},$$

$$r = \frac{\overline{na - s} \times 2}{2s - an + a \times n} : \text{and}$$

supposing $2sr + ra - 2a = z$,

$$n \text{ will be} = \frac{z + \overline{zz + 8sar}}{2ra}.$$

But when it is compound Interest

$$s \text{ will be} = \frac{a - \frac{a}{x^n}}{x - 1};$$

$$a = \frac{x^n \times \overline{x - 1} \times s}{x^n - 1};$$

$$n = \frac{L, a - L, \overline{a + s - sx}}{L, x};$$

$x = \frac{a}{s}$. And if n be supposed to become infinite; a being the annual Rent, it follows that $s =$

 sx

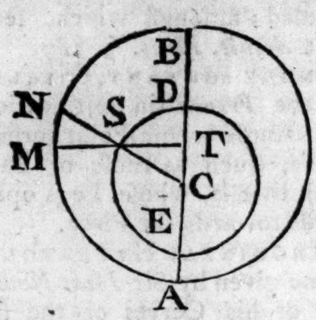
$s x - a$, so that from hence you may have Rules for buying and selling Estates in *Fee-simple* at compound Interest.

So that if it be required to find how may Years Purchase at compound Interest any Annuity is worth, n will be $= \frac{1}{x-1}$, and $x = \frac{n-1}{n}$

3. All this is from Mr. *Jones*'s *Synop. Palmar. Matheseos*, p. 208, *&c.* where the Investigation is shewn. As to the Doctrine of Annuities upon Lives, which is founded upon Bills of Mortality, see Dr. *Halley's Discourse* in the *Philosoph. Trans. N.* 196, and Mr. *De Moivre*'s Treatise of *Annuities*.

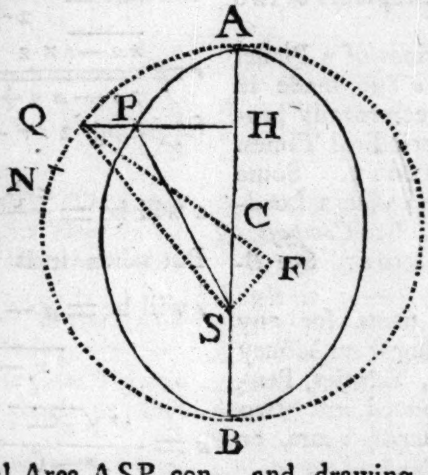
ANNULET. In Architecture, is a narrow flat Moulding belonging to the Capital or Base of a Column, being sometimes called a Fillet or *List*. *Harris* from *Ozanam* calls it a small square Part, turn'd about into the *Corinthian Capital*, under the *Echinus*, or Quarter Round.

ANOMALY, mean or simple, in the old Astronomy, is the distance of a Planet from the *Line* of the *Apses* according to its mean Motion: As let E S D be the Sun's Orbit, A M N B the Ecliptick, the Earth



at T, the Sun at S, and A B the Line of the Nodes; then is the Angle A T M or the Arch A M the Sun's mean Anomaly. *Ptolemy* calls it the *Angle of the mean Motion.*

But in the new Astronomy, where a Planet as P describes an Ellipsis A P B A about the Sun, situate in the Focus S, it is the Arch, or



Angle or Trilineal Area A S P contain'd under the Line of the Apses A B, (*viz.* the transverse Axis,) and the Line S P drawn to P the Planet's Place, which is proportional to the Time. Drawing the Perpendicular Q P H thro' P the Planet's place, and drawing S F perpendicular to the Radius Q C continued; the mean Anomaly may be represented by the trilineal circular Area A Q S, or by the Arch A Q + S F, as is demonstrated by Dr. *Keil* in his *Lect. Astron.* and others. The Ancients call,

call this the *mean Anomaly excentrick.*

It is easy to find the mean Anomaly; as may be seen in astronomical Writers. See *Kepler Epitom. Astron. Copernic. Lib.* 5. p. 686. and *Wolfius Elem. Astron.* §. 622.

ANOMALY EXCENTRICK OR OF THE CENTRE, is the Arch A Q of the excentrick Circle A Q B, and the right Line Q H drawn from the Centre of the Planet P, perpendicular to the Line A B of the Apses. This must be given in order to find the mean Anomaly, as may be seen, amongst others, in *Wolfius*'s *Elem. Astron.* §. 622.

ANOMALY COEQUATE OR TRUE, is the distance of the Sun from his *Apogæum*, or of a Planet from its *Aphelium*, where it is seen from the Sun; that is, it is the Angle A S P at the Sun, which the Planet's distance from the Aphelium A appears under. *Ptolemy* calls this *the Angle of the true Motion*, and some *the Angle of the Sun.*

It is not an easy Problem to find directly the true Anomaly from the mean one given; or, which is the same thing, to find the Position of a right Line S P passing thro' one of the *Focus's* S of a given Ellipsis, which shall cut off an Area P S A by its Motion, being to the Area of the whole Elipsis in a given Ratio, *viz.* in the Ratio of the periodick time of a Planet describing the Ellipsis to another given time; which being found, the Point P or Place of the Planet at that time will be had. *Kepler*, who first proposed this Problem, expresly owns that there is no direct way of solving it, that is, of finding the Angle P S A from the Area A P S. But he did it indirectly by the Rule of *False*, as may be seen in his Book before mentioned, p. 695. So also has *Wolfius Elem. Astron.* §. 628. Dr. *Wallis* first gave the geometrical Solution thereof by means of the protracted Cycloid. So has Sir *Isaac Newton* too in *Prop.* 31. *Lib.* 1. *Princip. Mathem. Philos. Nat.* These are ingenious indeed, but not fit for the purpose of an Astronomer, and therefore Sir *Isaac Newton* gave other Solutions by Series's, one of which may be seen in Dr. *Wallis*'s Works, *Vol.* 3. p. 625. and in *(Newton's) Fragmenta Epistolarum*, p. 26. And the other in the *Schol.* to the *Prop.* above mentioned; which last is much the best, being not only fit for the Planets, but even the Comets whose Orbits are very excentrick. Dr. *Gregory* in his *Astron. Lib.* 3. has also given a Solution by a Series, and *Reyneau* in his *Analyse Demontre, Lib.* 8. p. 713, 714. But Dr. *Keil*, in his *Prælection. Astron.* p. 375. is much better than theirs, it converging very fast. He says, if the Arch A N be the mean Anomaly, and its Sine be e, and Cosine f, and the Excentricity F C be g, and $g\ e$ be called z, then will A Q be $= \frac{r\,z}{a} - \frac{r\,z^3}{z\,a^3}$ &c. (supposing $r = 57°.\ 29578.$) = Degrees in that Arch; and the first Term $\frac{r\,z}{a}$ will be enough in all the Planets, even *Mars* it self, where the Error will not be more than the 200th part of a Degree; and from thence it will be easy to find the Angle A S Q, and afterwards the Angle A S P. See his Investigation, together with the Reason of what Sir *Isaac* says in the *Scholium* above mentioned; as also an Example of the Rule.

The Difficulty of this Problem made *Kepler* fly to other Suppositions about the Motion of the Planets, where he imagin'd some Point about which the Motion would be equable, when in reality there is no such Point. *Seth Ward*

too, in his *Aſtron. Geometr.* takes the Angle at the Focus, where the Sun is not for the mean Anomaly, which indeed will nearly repreſent it when the Orbit is not very excentrick, and then gives a very elegant Solution of the Problem. But if the Planet's Orbit be pretty excentrick, as is that of *Mars*; the Solution will not give the true Anomaly exact enough, as is ſhewn by *Bulialdus* in the Defence of the *PhilolaickAſtron.* againſt *Seth Ward*; where he ſhews from four Places of *Mars* obſerved by *Tycho Brahe*, that in the firſt and third Quadrants of the Anomaly, the Place of *Mars* is forwarder than it ſhould be, and in the ſecond and fourth Quadrants, the true Anomaly is too little, and gives a Correction; but this Correction is not ſo good as that of Sir *Iſaac Newton* at the end of the *Scholium* above mentioned

Anser. A ſmall Star of the fifth or ſixth Magnitude in the *Milkey-Way*, between the Swan and Eagle, firſt brought into order by *Hevelius.* See his *Prodrom. Aſtron.* p. 117. 308. and *Firmamen. Sobieſcan. Fig.* L.

Anses, or *Anſæ*, *Handles*; the parts of *Saturn's* Ring, which are to be ſeen on each ſide the Planet when viewed through a Teleſcope, and the Ring appears ſomewhat open. See *Ring of Saturn.*

Antares. A Star of the firſt Magnitude in *Scorpio.* It is call'd *the Scorpion's Heart. Hevelius* in his *Prodrom. Aſtron.* p. 300. makes its Longitude for the Year 1700 in ♐ 5°. 32′. 43″. and ſouthern Latitude 4°. 27′. 19″.

Antarctick Pole, is the ſouthern Pole, or ſouthern End of the Earth's Axis.

Antarctick Circle, the ſame with *Polar Circle.* Which ſee.

Antecedentia, or *in Antecedentia.* A Planet, Comet or Point of the Heavens, is ſaid to be *in Antecedntia*, when it moves contrary to the Order of the Signs, *viz.* from *Taurus* to *Aries*, &c.

Antecedent, is the firſt of two Terms of a *Ratio*, or that which is compared with the other; as in the Ratio of 2 to 3, or *a* to *b*; 2 and *a* are each *Antecedents.*

Antes. In Architecture, are ſquare Pilaſters placed at the Corners of Buildings. See *Vitruvius, Lib.* 3. C. 1. The *French* call theſe ſometimes *angular Pilaſters*, as may be ſeen in *Daviler*, p. 35. See alſo *Goldman's* Treatiſe of Architecture, *Lib.* 1. p. 10. and *Wolfius's Elem. Architect.* §. 75. As likewiſe *Perrault* upon *Vitruvius*, p. 22, 23, and 26. m. 62, and 64.

Antepagments. *Vitruvius* in *Lib.* 4. C. 6. calls by this Name the Ornaments of Doors and Windows, from whom Mr. *Perrault* has tranſlated it in *French* by the Word *Chambranles*, and the *French* ſometimes uſe it in the ſame Senſe with *Tablette*, and the *Italians*, with *il pianazzo*, as may be ſeen in *Scamozzi.*

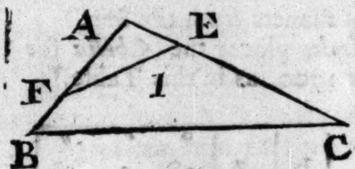
Anticks, in Architecture, are the Figures of Men, Beaſts, &c. placed for Ornaments to Buildings.

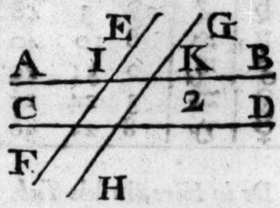
Antæci, in Geography, are the Inhabitants of the Earth, which live in the ſame Semicircle of the ſame Meridian, but on different Sides of the Equator, *viz.* the one North and the other South. But equally diſtant from the Equator.

Theſe have Noon and Midnight, and all Hours at the ſame time. But contrary Seaſons of the Year, that is, when it is Spring to one, it is Autumn to the other; when Summer to the one, Winter to the other. The Days of the one are equal to the Nights of the other, and *vice verſâ.* See other Affections of the *Antæci* in *Varen. Geogr.* c. 8. *Prop.* 4. *Sect.* 6.

Antilogarithm, is the Logarithm of the Co-ſine or Co-tangent or Co-ſecant of any Sine, Tangent, or Secant; which how to find, ſee in Books of Trigonometry.

Antiparallels, are those Lines, as F E, B C, that make the same Angles A F E, A C B, with the two





Lines A B, A C, cutting them, but contrary ways, as parallel Lines that cut them. But Mr. *Leibnitz*, in the *Acta Erudit.* An. 1691. p. 279. calls Antiparallels those Lines (see Fig. 2.) as E F, G H, which cut two Parallels A B, C D; so that the outward Angle A I F, together with the inward one A K H, is equal to a right Angle.

When the Sides A B, A C of a Triangle, as A B C (Fig. 1.) are cut by a Line E F antiparallel to the Base B C, the said Sides are cut reciprocally proportional by the said Line E F; that is, A F : B F :: E C : A E, the Triangles A F E, A B C being similar or equiangular.

Antipodes, in Geography, are the Inhabitants of two Places that live diametrically opposite to one another, or that walk Feet to Feet, being 180 Degrees distant from one another; that is, if a Line was continued down from our Feet quite thro' the Centre of the Earth till it arrived at the Surface on the other Side, it would fall upon the Feet of our *Antipodes*, and *vice versa*. If one was continued in like manner from their Feet, it would fall upon ours, who are their *Antipodes*. The *Antipodes* have Summer when we have Winter, and Winter when we have Summer, Day when we have Night, and Night when we have Day. See the Affections of these in *Varen. Geogr. Cap.* 28. *Prop.* 9. *Sect.* 6.

In former times it was taken for a great Fable for any one to say there were People that walked with their Feet to ours, and the ancient Fathers, St. *Augustin lib.* 16. *de Civitate Dei*, c. 9. and *Lactantius Instit. divin. lib.* 3. c. 24. strenuously denied it as well as others.

Antique. A Building or Statue made when Building and Satuary were at the utmost Perfection amongst the ancient Greeks and Romans.

Antiscii, in Geography, are those Inhabitants of the Earth which live in two Places on the same Meridian equally distant from the Equator, the one on the North, and the other on the South Side thereof; the one having Summer when the other has Winter, and contrary wise; and when the Days of the one are longest, those of the other are shortest. See more of the Affections of these in *Varen. Geogr. general.* as also *Wolfius*'s *Geogr. Cap.* 6.

Aperture, in Opticks, is a round Hole (whose Diameter is a little less than that of the Object-Glass) in a turn'd bit of Wood or Plate of Tin, placed within side of a Telescope or Microscope near to the Object-Glass, by means of which you get an Admittance of more Rays, and a more distinct Appearance of the Object.

Mr. *Huygens*, (in his *System of Saturn*, p. 82. and *Dioptr. Prop.* 53. p. 195.) first found the use of Apertures to conduce much to the perfection of Telescopes; and in his *Dioptr. Prop.* 56, p. 205. & *seq.* he found by Experience that the best Aperture for an Object Glass of 30 Feet is as 30 to 3, or 10 to

to 1; that is, as 10 to 1, ſo is the ſquare Root of the focal Diſtance of any Lens multiplied by 30 to its proper Aperture; and that the focal Diſtance of the Eye Glaſſes are proportional to the Aperture. It has alſo been found by Experience, that Object Glaſſes will admit of greater Apertures, if the Tubes be blackened within ſide, and their Paſſage be furniſhed with wooden Rings.

Mr. *Auzout* ſays, that he found by Experience that the proper Apertures of Teleſcopes ought to be nearly in the ſub-duplicate Ratio of their Length. Whether this be true, I know not.

APHELIUM, or APHELION, is that Point of any Planet's Orbit, in which it is at the fartheſt Diſtance from the Sun; being, in the Copernican Aſtronomy, that end of the greater Axis of the elliptical Orbit of the Planet, moſt remote from the Focus wherein the Sun is.

The times of the Aphelia of the primary Planets, may be known by their apparent Diameters appearing leaſt, as alſo by their moving ſloweſt in a given time. You will ſee how to find them by Computation in *Wolfius*'s *Elem. Aſtron.* §. 659, 667. In *Ricciolus*'s *Almag. Nov. lib.* 7. *Sect.* 2. *f.* 543. and *foll.* and *Sect* 3. *Cap.* 8. and *foll. f.* 586. and *foll.* See alſo *Street*'s *Aſtron. Carolin. p. m.* 25. and *foll.* Dr. *Halley* too has given a way to find them in the *Philoſoph. Tranſ. n.* 128. and ſo has Dr. *Gregory* in his *Aſtron. lib.* 3. *prop.* 14. and Dr. *Keil* in his *Aſtronomical Lectures.* Theſe laſt being the beſt of any.

Sir *Iſaac Newton*, in *prop.* 14. *lib.* 3. of his *Princip.* as alſo Dr. *Gregory* in his *Aſtronomy* prove the Aphelia of the primary Planets to be at reſt; tho' at the ſame time, in the *Scholium* to the ſaid Propoſition, he ſays the Planets neareſt to the Sun, *viz. Mercury*, *Venus*, the Earth and *Mars*, from the Actions of *Jupiter* and *Saturn* upon them, move a ſmall matter *in Conſequentia* with reſpect to the fixed Stars, and that in the *ſeſquiplicate* Ratio of the Diſtance of theſe Planets from the Sun.

Kepler places the *Aphelia* for the Year 1700, as in this Table.

		°	′	″
♄	♐	28	3	48
♃	♎	8	10	40
♂	♏	0	51	29
♀	♒	3	24	27
☿	♑	8	25	30

But *De la Hire*, in his *Tab. Aſtron.* will have them to be for the ſame Year as in this other Table.

		°	′	″
♄	♐	29	14	41
♃	♎	10	17	14
♂	♏	0	35	25
♀	♒	6	56	10
☿	♑	13	3	40

And makes the yearly Motions of them to be thus,

	′	″
♄	1	22
♃	1	34
♂	1	7
♀	1	26
☿	1	39

APOGÆUM. That Point of the Orbit of the Moon or Sun, (in the old Aſtronomy) which is fartheſt from the Earth.

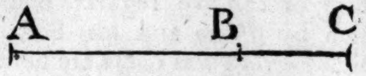
The manner of finding the Apogæum of the Sun or Moon, is ſhewn by *Wolfius* in *Elem. Aſtron.* §. 618. and by *Ricciolus* in *Almag. Nov. lib.* 3 *cap.* 24. alſo by *Street* in *Aſtron. Carolin. p. m.* 7. You have alſo a Geometrical way of finding the ſame by Mr. *Caſſini.* See *Tranſ. Philoſoph. n.* 57. *De la Hire* in *Tab. Aſtron. p.* 15. makes the Apogæum of

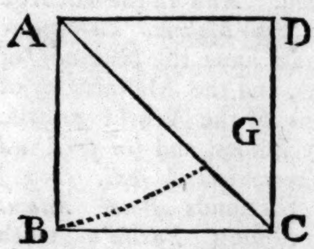
of the Sun to be in 8° 7′ 30″ of ♋ and its annual Motion 1′ 2″ and the Apogæum of the Moon in 6° 53′ 40″ of ♓, and its annual Motion 1 *ſi.* 10° 39′ 52″.

The Moon's Apogæum moves unequally; when ſhe is in the Syzygy with the Sun, it goes forwards, and in the Quadratures, backwards; and theſe Progreſſions and Regreſſions, are not equable, but it goes forward ſlower when the Moon is in the Quadratures, or perhaps goes backwards; and when the Moon is in the Syzygy, it goes forwards faſteſt of all. See more of the Apogæum of the Sun and Moon, in Sir *Iſaac Newton*'s Theory of the Moon.

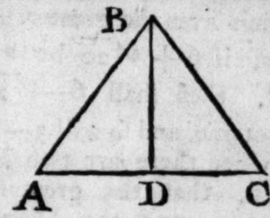
Apophyge, in Architecture, is a concave Part or Ring of a Column, lying above or below the flat Member. The *French* call it *Le Congé d'en Bas*, or *d'en Haut*; the *Italians*, *Cavo da Baſſo*, or *di Supra*, as alſo *Il vivo da Baſſo*. Amongſt the ſeveral Authors that tell how to deſcribe it, ſee *Wolfius*'s *Elem. Arch.* §. 115.

Apotome. *Euclid* in his tenth Book at *Prop.* 74. calls an *Apotome* a Line BC which is the Difference between a rational Line AC, and a Line A B only commenſurable in power to the whole Line A C, and may be

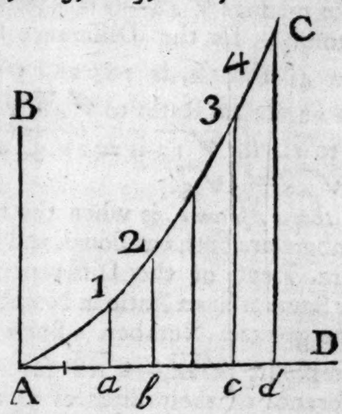




expreſſed thus; ſuppoſing (A C$=a$ and A B$=b$,) *viz.* $a-\sqrt{b}$, or in Numbers $2-\sqrt{3}$. Hence the difference G C between the Side A B$=1$ of a Square, and its Diagonal A C$=\sqrt{2}$, will be an *Apotome*, *viz.* equal to $1-\sqrt{2}$; ſo alſo will the Difference between the Side A



C$=2$ of an equilateral Triangle A B C, and the perpendicular B D$=\sqrt{3}$, be an Apotome, *viz.* $=2-\sqrt{3}$: And generally if A C be a Semi-parabola, whoſe Axis is A B, and Latus Rectum be$=1$, and if AD be a Tangent to the Vertex at A, and this be divided into the Parts A $a=2$, A $b=3$, A $c=5$, A $d=6$. &c. and Perpendiculars a 1, b 2, c 3, d 4, &c, be drawn, theſe will be (from the nature of the Curve) $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, $\sqrt{6}$, &c. reſpec-



tively; and ſo $\frac{1}{2}$ A a $(=1)-$ a 1, will be $1-\sqrt{2}$; A $a-b$ 2 will be $2-\sqrt{3}$; A $b-c$ 3 will be $3-\sqrt{5}$; A $c-d$ 4 will be $5-\sqrt{6}$, &c. Wherefore by this means you will have an infinite Series of different Apotomes.

Euclid in *lib.* 10. (ſee his third Definition after *Prop.* 85) diſtinguiſhes Apotomes into firſt, ſecond,

 third,

third, fourth, fifth, and fixth; and in the Propofitions immediately following, fhews how to find each of them, being indeed no other than the Subductions of the leffer Names or Parts of Binomials from the greater. As in Numbers, if $6+\sqrt{20}$ be a firft Binomial, then fhall $6-\sqrt{20}$ be a firft Apotome, and fo will $3-\sqrt{5}$; that is, when there are two Numbers fuch, that the greateft is a rational one, and the Difference between their Squares is a fquare Number.

A fecond *Apotome*, is when the leaft Number is rational, and the fquare Root of the Difference of the Squares of the two Numbers, has a Ratio in Numbers to the greateft Number. Such is $\sqrt{18}-4$, for the Difference between the Square 18, and 16 the Square of 4, is 2, and $\sqrt{2}$, has a numerical Ratio to $\sqrt{18}$, *viz.* as 1 to 3; for $\sqrt{18}$ is $=3\sqrt{2}$; in like manner $\sqrt{48}-6$ is a fecond Apotome; for the Difference between 48 and 36, is 12, and $\sqrt{12}$ has a numerical Ratio to $\sqrt{48}$, *viz.* as 2 to 1, for $\sqrt{12}$ is $=2\sqrt{3}$, and and $\sqrt{48}=4\sqrt{3}$.

A third Apotome, is when the two Numbers are both irrational, and the fquare Root of the Difference of their Squares has a Ratio in Numbers to the greateft Number. Such for Example is, $\sqrt{24},-\sqrt{18}$ for the Difference of their Squares 24 and 8, is 6, and $\sqrt{6}$ has a numerical Ratio to $\sqrt{24}$, *viz.* as that of 1 to 2, for $\sqrt{24}$ is $=2\ \sqrt{6}$.

A fourth Apotome, is when the greateft Number is rational, and the fquare Root of the Difference of the Squares of the two Numbers, has not a Ratio to that. Such is $4-\sqrt{3}$, where the Difference of the Squares 16 and 3 is 13, and $\sqrt{13}$ has not a Ratio in Numbers to 4.

A fifth Apotome, is when the leaft Number is Rational, and the fquare Root of the Difference of the Squares of the two Numbers has not a Ratio in Numbers to the greateft. Such is $\sqrt{6}-2$ where the Difference of the Squares 6 and 4 is 2, and $\sqrt{2}$ to $\sqrt{6}$ has not a Ratio in Numbers.

A fixth Apotome, is when both the Numbers are irrational, and the fquare Root of the Difference of their Squares has not a Ratio in Numbers to the greateft. Such is $\sqrt{6}-\sqrt{2}$, where the fquare Root $\sqrt{4}=2$ of the Difference (4) of the Squares of 6 and 2 has not a Ratio in Numbers to $\sqrt{6}$.

The Doctrine of Apotomes in Lines, as handled by *Euclid*, in his tenth Book, is a very curious Subject, and worthy to be perufed and improved by all thofe who would lay down geometrical Elements, from whence might be deduced the Poffibility or Impoffibility of the Quadratures, of Curve-lineal Figures, and perhaps lineal Solutions of *Diophantus*'s Problems, and others of the like kind, tho' all the ufe, (one would think) *Euclid* himfelf made of this Book, was only to fhew the nature of the five regular Bodies, which by *Plato* and his Sect (of which *Euclid*'s was one) were held in great Efteem. And in the laft Age *Kepler* (in his *Myfteria Cofmographica*) would have the Number of the Planets, and the Magnitudes of the Syftems of the World to arife from thefe Bodies, and (*in pref. ad lib.* 1. *Harmonices Mundi. f.* 3.) fharply reprimands *Peter Ramus* for undervaluing *Euclid*'s tenth Book (*in lib.* 21. *Scholarum Mathematicarum, p.* 252.) *Kepler* fays, *Veftrum eft carpere, quæ non intelligitis, mihi qui rerum Caufas indago, præter-*

præterquam in decimo Euclidis semite ad illas nullæ patuerunt. And *Ramus* says, *Materies decimo Libro proposito eo modo est tradita, ut in humanis literis atque artibus similem obscuritatem nusquam deprehenderim: obscuritatem dico non ad intelligendum, quid præcipiat Euclides, —sed ad perspiciendum penitus et explorandum quis finis & usus sit operi propositus, quæ genera, species, differentiæ sint rerum subjectarum: nihil enim unquam tam confusum vel involutum legi vel audivi.*

Old *Oughtred* in his *mathematical Key* has a Declaration of the tenth Book of *Euclid*, demonstrated by *Symbols*. Dr. *Barrow* too in his *Euclid* has done the same. You have also in *Michael Stifel* his *Arithmetica Integra*, *lib.* 2. c. 13. and fol. p. 143. and *fol.* The aforesaid Book of *Euclid*, and also the Doctrine of Apotomes clearly explain'd and fully handled at *Cap.* 23. p. 187. and fol.

Apotomes are also called *residual*, and *residual Binomials*.

Apotome, by some Writers on the Theory of Musick, is the Difference between a greater and lesser Semi-tone, being expressed by the Ratio 128 : 125.

Apparent Diameter, in Astronomy, is the Angle under which we see the Sun, Moon and Stars: As when we see the Sun S under the Angle DOE; this Angle is the Apparent Diameter. The apparent Diameters of the Sun, Moon, and Planets must be known, in order to compare the Bignesses of them with each other, to know how much one is bigger or less than another, and to compute the true Magnitude of either of them.

Because the Sun and Moon have much greater apparent Diameters than the rest of the Planets; the ways to observe the Quantity of these are different from those, whereby those of the rest of the Planets are had. *Ricciolus* (in *Almag. nov. lib.* 3. c. 10. f. 16. and fol.) gives five different ways to observe the apparent Diameter of the Sun, and eight ways for those of the Planets and fix'd Stars, (in *lib.* 6. c. 9. f. 422. and *fol.*) The best way of doing this in general, is by a Micrometer fix'd in the Focus of a Telescope. See *Micrometer*.

1. One way of finding the apparent Diameter of the Sun, is by taking the meridian Altitudes of his upper and lower Limbs, with a good Quadrant and Telescope fitted to it, and afterwards taking their Difference, which will be his apparent Diameter seen from the Earth.

2. Another way is, by erecting two perpendicular Threads over the Meridian Line, and while the Eye is at rest observing the Sun's Passage over the Meridian, and noteing the Instant that the Limb of the Sun comes to the Threads, by an accurate Time-Keeper or Clock, and the Instant that its opposite Limb leaves them; and the Difference is the Time wherein the Diameter of the Sun is passing over the Meridian: which if the Sun be in the Equator, this Time turn'd into Minutes, &c. of a Degree, will be the Angle under which the Sun appears. But if the Sun be out of the Equator, the Arch found is one in that parallel Circle the Sun moves in, which must be turn'd into Minutes, &c. of the Equator.

3. The Diameter of the Sun, Moon and Planets is not found to be the same at all times; but in each of them it increases to a certain Limit; and then again decreases. And particularly it is found that

that the superior Planets appear much greater when they are in opposition to the Sun, than when near a Conjunction; and the inferior Planets appear greater, when their Light is lessen'd, than when they shine more bright; and particularly *Ricciolus* says (in *Almagest. Nov. lib.* 7. *sect.* 6. c. 10. f. 713.) that the Diameter of *Mars* is almost nine times greater when in opposition to the Sun, than when it is near a Conjunction; so that in *July* and *August*, in the Year 1529, it was taken for a new Star, by reason of its prodigious Magnitude. See *Kepler* in *Astronom. Optic.* c. 10. p. 333.

4. The apparent Diameter of the Sun was observed by

	greatest.		mean.		least.	
	′	″	′	″	′	″
Ptolemy (in his *Almag. lib.* 5. c. 14. f. m. 117.)	33	20	32	18	31	20
Tycho Brahe (in his *Progymnasin. lib.* 1. c. 1. p. m. 135.)	32	0	31	0	30	0
Kepler (in his *Tab. Rudolph.* f. 92.)	31	4	30	30	30	0
Ricciolus (*Astron. Reform. lib.* 1. c. 12. f. 38.	32	8	31	40	30	0
Cassini (see in *Ricciolus* above)	32	10	31	40	31	8
De la Hire (in *Tab. Astron.*)	32	43	32	10	31	38

And now-a-days it is observ'd that the Sun's apparent Diameter is least when he is in ♋, and greatest when in ♓.

5. There is a two-fold Increase and Decrease of the Moon's apparent Diameter, the one in the Conjunctions and Oppositions, and the other in the Quadratures; for the apparent Diameter in those is less, and in these greatest; and the least in those is less than the least in these. In the first Case we have by

	greatest.		least.	
	′	″	′	″
Ptolemy (in the Place as above.)	31	20	35	20
Tycho (in the *Conjunct.*)	25	36	28	48
Tycho (in the *Opposition.*)	32	0	36	0
Kepler.	30	0	32	44
De la Hire.	29	30	33	30

In the latter Case by

	least.		greatest.	
	′	″	′	″
Ptolemy.	42	8	55	0
Tycho Brahe.	32	32	36	0

6. *Hevelius* (*in Tractatu de Mercurio in Sole viso, f.* 101.) exhibits the apparent Diameter of the superior Planets by different Authors as follows.

		least.			mean.			greatest.		
		′	″	″	′	″	″	′	″	″
Albategnius	♄	1.	29.	13	1.	44.	13	2.	5.	59
Tycho		1.	34.	0	1.	50.	0	2.	12.	0
Keplerus		0.	21.	0	0.	25.	0	0	38.	0
Ricciolus		0.	46.	0	0.	57.	0	1.	12.	0
Hevelius		0.	14.	10	0.	16.	2	0.	19.	40
Albategnius	♃	2.	9.	25	2.	36.	40	3.	18.	24
Tycho		2.	4.	0	2.	45.	0	3.	59.	0
Keplerus		0.	30.	0	0.	38.	0	0.	50.	0
Ricciolus		0.	38.	18	0.	49.	46	1.	8	46
Hevelius		0.	14.	36	0.	18.	2	0.	24.	22
Albategnius	♂	0.	54.	0	1.	34.	0	6.	10.	0
Tycho		0.	57.	0	1.	40.	0	6.	46.	0
Keplerus		0.	54.	0	1.	34.	0	6.	30.	0
Ricciolus		0.	10.	0	0.	22.	0	1.	32.	0
Hevelius		0.	2.	46	0.	5.	2	0.	20.	50
Albategnius	♀	1.	49.	0	3.	8.	0	16.	42.	0
Tycho		1.	52.	0	3.	15.	0	4.	40.	0
Keplerus		1.	2.	0	1.	48.	0	7	6.	0
Ricciolus		0.	33.	30	1.	4.	12	4.	8.	0
Hevelius		0.	9.	34	0.	16.	46	1.	5.	58
Albategnius	☿	1.	27.	21	2.	5.	20	3.	41.	45
Tycho		1.	29.	0	2.	10.	0.	3.	57.	0
Ricciolus		0.	9.	20	0.	13.	48	0.	25.	12
Hevelius		0.	4.	4.	0.	6.	3.	0.	11.	48

7. Mr. *Huygens*, (in *Syſtem. Saturnino*, p. 77. and *fol.*) has obſerved, by the moſt exact Method, the leaſt Diameter of ♄ to be 30″; of its Ring 1′8″; of ♃, to be 1′. 4″; of ♂, to be 30″; of ♀, to be 1′. 25″. *Hevelius* found the apparent Diameter of *Mercury*, when ſeen in the Sun, to be not more than 11″ 4‴.

8. The great Difference between the apparent Diameter, as given by the Ancients, from what the Moderns obſerve them to be, is, that (thoſe, ſuch as *Albategnius* and *Tycho*,) they took them by the naked Eyes only; but the Moderns uſe Teleſcopes, by which the falſe Light cauſing them to appear bigger then really they are, is removed. Indeed *Ricciolus* uſed Teleſcopes; but then he wanted a Micrometer: without which the thing cannot be accurately performed. As to the apparent Diameters of the fix'd Stars, by the beſt Inſtruments that have been yet invented, they have hitherto appeared but as ſo many Points. Even Mr. *Huygens* ſays, he found the apparent Diameter of the Dog-ſtar not to be more than 4‴.

Apparent Distance, is that Diſtance which we judge an Object to be from us when ſeen afar off, being moſt commonly very different from the true Diſtance; becauſe we are apt to think that all very remote Objects, whoſe Parts cannot well be diſtinguiſhed, and which have no other Object in view near them, to be at the ſame Diſtance from us, tho' perhaps they may be thouſands of Miles, as in the Caſe of the Sun and Moon.

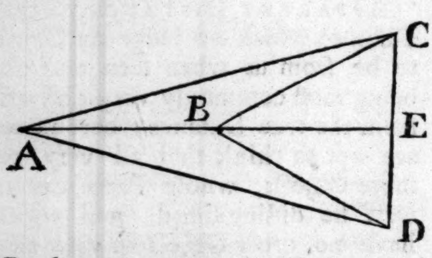
Apparent Figure, is that Figure

Figure or Shape which an Object appears under when view'd at a Diſtance, being often very different from the true Figure. For a ſtreight Line, view'd at a Diſtance, may appear but as a Point; a Surface, as a Line; and a Solid, as a Surface; and each of theſe of different Magnitudes, and the two laſt of different Figures, according to their Situations with regard to the Eye. Thus an Arch of a Circle may appear a ſtraight Line, a Square or Oblong a Trapezium, or even a Triangle, a Circle, an Ellipſis; angular Magnitudes, round; a Sphere, a Circle, *&c.*

Alſo any ſmall Light (as a Candle, Link, *&c.*) ſeen at a diſtance in the Dark, will appear magnified, and farther off than really it is.

Add to this, that ſeveral Objects ſeen at a diſtance under Angles that are ſo ſmall as that each of them is inſenſible, as well as each of the Angles ſubtended by any one of them, and that next to it; I ſay all theſe Objects will appear to be contiguous, to conſtitute, and ſeem but one continued Magnitude.

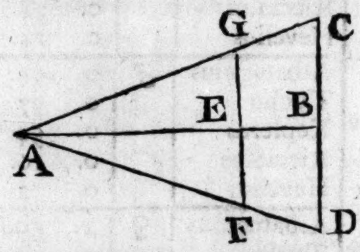
Apparent Magnitude *of an Object*, is the Magnitude of an Object as it appears to the Eye, and its Meaſure is the Quantity of the Optick Angle; as let D C be an Object view'd by an Eye at A and



B, then the Angle C A D is the *apparent Magnitude* of that Object ſeen at A, and the Angle C B D, its *apparent Magnitude*, when view'd at B.

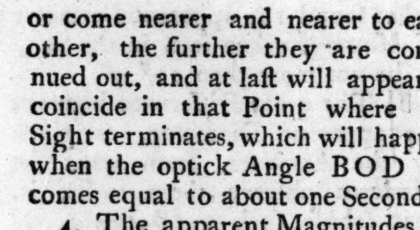
1. All things appear the leſs, the more remote they are; and it is found by Experience when their Diſtance becomes ſo great that the apparent Magnitude is no more than an Angle of one ſecond, they will become ſo ſmall as to appear but like a Point, and be no more ſeen.

2. Thoſe things G F and C H which appear under the ſame Angle



C A H, have their Magnitudes proportional to their Diſtances A E, A B.

3. If the Eye O be placed between two Parallels A B, CD, theſe Parallels will appear to converge



or come nearer and nearer to each other, the further they are continued out, and at laſt will appear to coincide in that Point where the Sight terminates, which will happen when the optick Angle B O D becomes equal to about one Second.

4. The apparent Magnitudes of the ſame Object D C, (ſee Fig. above) ſeen at the Places A and B, that is, the Angles C A D, and C B D, are in a Ratio leſs than the reciprocal Ratio of the Diſtances A E and B E; but when the Object is very remote, or the optick Angles C A B, C B D not above one Degree or thereabouts,

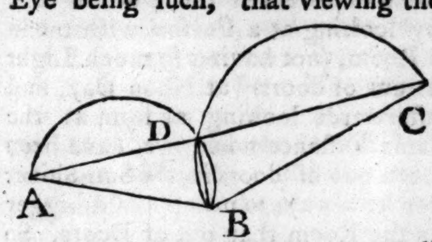
bouts, they are nearly as the Distances reciprocally.

5. Any Chord A B of a Circle will appear of the same Magnitude from any Point, as C of the Periphery; so that the best Figure for a

Theatre is the Segment of a Circle, where the Actors are in a Chord, and the Spectators in the Periphery.

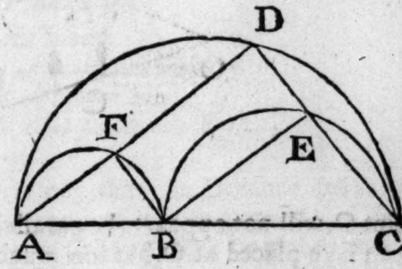
6. The equal Parts of the same Line appear unequal, also equal Objects at the same Distance, but some more oblique to the Eye than others; those will appear to be biggest that are more direct to the Eye.

7. To find the Position D of the Eye being such, that viewing the



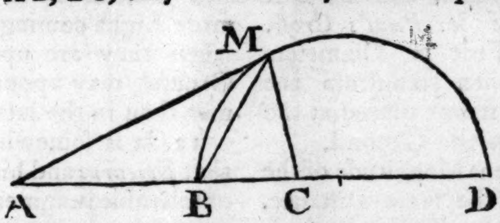
unequal Objects A B, B C, they shall appear of the same bigness. This is done by describing two similar Segments of Circles upon each of the Lines, and their Point D of Intersection will be the Point sought; and indeed the Curve in which all such Points D do fall, will be one of the fifth order, as it is easy to find by Computation.

8. If three Situations F, D and E, of the Eye be wanted, such, that any given Parts A B, B C, of an



Object A C, as also the whole Object shall all appear of the same Magnitude; it is but describing three Semi-circles, or three similar Segments of Circles upon the said Parts, and the whole Object; and the said Parts and Whole will appear of the same Magnitude from any Points F, D and E, in the respective Peripheries of those Circles.

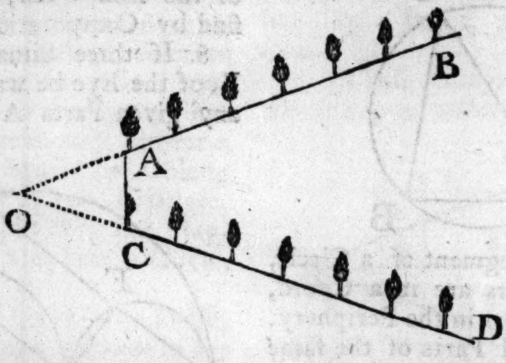
9. And if it were required to find the Locus of the Point M, being such that an Eye placed at it shall always see unequal Parts, A B, B C



of the same Object, of the same Magnitude, it is but continuing out B C the lesser Part to D, so that CD be a fourth Proportional to B C, A C, and describing a Semi circle upon B D; for if from any Point M of this Semi-circle, the right Lines M A, M B, M C be drawn; the Angles A M B, B M C will be equal.

10. Altho' the optick Angle be the usual Measure of the apparent Magnitude

nitude of an Object, yet Custom and the frequent Experience of looking at distant Objects, by which we know they are bigger than they appear, has so far prevail'd upon the Imagination, as to cause this too, to have some share in our Estimation of the apparent Magnitude; so that the apparent Magnitude of an Object will be judged to be more than in the Ratio of the optick Angle; and perhaps this may be the whole (or at least Part of the Cause) why two Rows of Trees A B, C D placed in two right Lines A B, C D, meeting in the



Point O, will not appear to be parallel to an Eye placed at O, but too much diverging; when nevertheless, if the optick Angle be the sole measure of the apparent Magnitude, they must appear parallel; and I doubt not but would do so, to one that should look at them just after he was recover'd from a Blindness which he always had before. This too may be part of the Reason why an Object at a considerable Distance horizontally appears bigger, than when at the same Distance vertically; as the Sun and Moon near the Horizon appear bigger than when in the Meridian, and the Ball (for Instance) of *St. Paul's Cross*, which is six Feet in Diameter, appears less when seen from the Ground, than if it was placed at the same Distance on the Ground.

11. The apparent Magnitude of the same Object at the same Distance, will be different to different Persons, and different Animals, and even to the same Person, when view'd in different Lights; all which may be occasion'd by the different Magnitudes of the Eye, causing the optick Angle to differ as that is bigger or less; and since in the same Person the more Light there comes from an Object, the less will the Pupil of his Eye, looking at that Object, be; the optick Angle will be less too, and so will the apparent Magnitude of the Object. I have often experienced the truth of this, by looking at a Person with me in a Room, (not having so much Light as out of doors) at Noon Day, and afterwards looking at him at the same Distance when we have been both out of doors in the Sun-Shine, for he always to me appear'd bigger in the Room than out of Doors. So also Objects up in the Air, having more Light coming from them than when they are upon or near the Ground, may appear less in the former than in the latter Case.

12. It is somewhat extraordinary that *Epicurus* and his Followers (Men of tolerable Judgment in many things) should be so stupid and enormously mistaken, when they say the Sun, Moon, and Stars are no bigger than they appear to be. We find *Epicurus* himself asserting this in his Epistle to *Pythocles*, to be seen in

Epicurus's

Epicurus's Life given by *Diogenes, Laertius, lib.* 10. *Lucretius* too in *lib.* 5. *de Natura Rerum* sings the same in these Words,

Nec nimio solis major rota nec minor Ardor
Esse potest, nostris quam sensibus esse videtur.

And again,

Lunaque sive Notho fertur loco Lumine lustrans,
Sive suam proprio jactat de Corpore Lucem,
Quicquid id est nihilo fertur majore Figura,
Quam nostris oculis quam cernimus esse videtur.

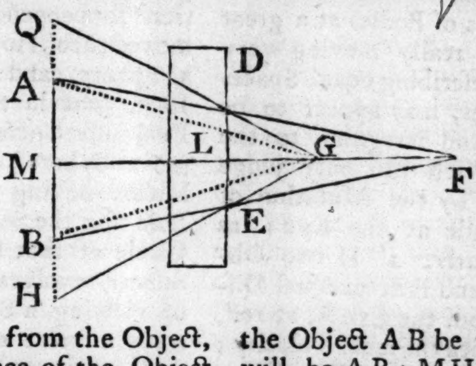
Thus rendered into *English* by *Creech*,

But farther on: The Sun and Moon do bear
No greater Heats, nor Figures than appear.
——————*And thus the Moon,*
Whether with borrow'd Rays or with her own,
She views the World, carries no larger Size,
No fiercer Flames, than those that strike our Eyes.

Our blundering *Hobbes* too affirms the same thing.

The chief Reason they give is, "That as we retire from any Fire, "so long as we are within such a "Distance from it, that we can "perceive its Light and Heat, the "Fire seems no less than it does "when we are near it; but we "feel the Heat, and perceive the "Light of the Sun; therefore the "Sun is of the same Magnitude as "it appears to be; and as to the "Moon, we see the utmost Verge "and Face of it distinctly, which "we should not do, if it were so far "off, that its Distance took away "any of its Magnitude.

13. If the Eye be placed in a rare Medium, and views an Object thro' a denser, as Glass or Water, having plane Surfaces; that Object will appear bigger than it is, and contrarywise. And in each Case the apparent Magnitude QH will be to the true Magnitude AB, in a Ratio compounded of FL the Distance of the Point F, to which the Rays from B and A go unrefracted from the refracting Surface, to the Distance GL of the Eye from the same, and of the Distance



GM of the Eye from the Object, to FM the Distance of the Object from the same: that is $QH : AB :: FL \times GM : GL \times FM$. And if the Object AB be very remote; it will be $AB : MH :: GL : FL$; for in this Case FM will be nearly $= GM$, and the nearer the Object is

is to the Surface (of the Medium next to it) the bigger it will appear to be, even till it touches that Surface where it is seen at its greatest Bigness; and coming within the Medium, it will again become less, (tho' it will still appear greater than it really is) the nearer it approaches the Surface next to the Eye. And hence it is that Fishes or any thing else, seen in the Water from one in the Air, appear bigger than when in the Air.

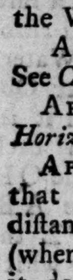
14. The apparent Magnitude of an Object will also be augmented, by looking at it thro' a Globe of Glass, or Water, or any convex spherical Segments of these; and on the contrary, it will be diminished, when view'd thro' a Concave of Glass, or Water. See more under the Word *Lens*.

Apparent Conjunction. See *Conjunction apparent*.

Apparent Horizon. See *Horizon*.

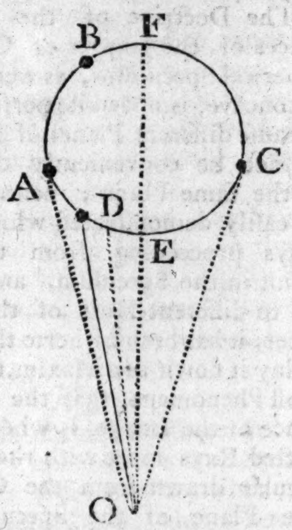
Apparent Motion, is either that Motion which we perceive a distant Body really moving to have (when we perceive it move, or know it does by its change of Place) while the Eye is at rest or in motion, or that Motion which an Object at rest seems to have, while the Eye is in motion.

The Motions of Bodies at a great Distance, tho' really moving very equally, and describing equal Spaces in equal Times, may appear to be very unequal and irregular to the



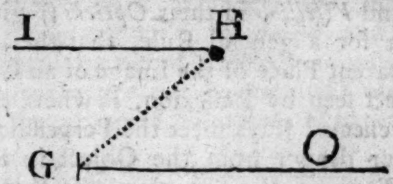
Eye, which can only judge of them by the Mutation of the Angle at the Eye; as particularly, 1. If two Objects B and E at unequal Distance from the Eye A, at rest, move with the same Velocity; the most remote E will appear to move the slowest; and, 2. If their Velocities be proportional to their Distances AB, AE from the Eye, they will seem to move with the same Velocity. 3. But if the most remote E, move slower than the nearest, the Motion of the nearest will appear to be much swifter than it is. And if they both move the same way, the apparent Velocities are in a Ratio compounded of the direct Ratio of the true Velocities, and the inverse Ratio of the Distances AB, AE from the Eye. 5. The Object E moving with any Velocity whatever, will seem to be at rest, if the Ratio of the Space it really describes in one Second of Time, be to the Distance thereof from the Eye, as 1 to 1400, or as even 1 to 1300. For since the Motion of the Hour-Hand of a Clock, and the Motion of the Stars about the Earth, are not visible to the Eye, and in one Second of Time, an Arch of 15 Seconds is pass'd over; it is evident the way moved thro' by a moveable Body is imperceptible, if it be seen under an Angle of 15 Seconds, and much more so, when it appears under a less Angle. 6. It is possible for the Motion of a Body to be so swift, as that throughout the whole Space it describes there shall constantly appear a Solid, as it were generated by the Motion of the greatest Section thereof, (which Section is perpendicular to the way moved thro') so that if the Body be a Sphere, and it moves in a right Line, (not in the Direction of the Eye) instead of seeing the said Sphere, (as a Sphere,) you will see a Cylinder, having the Diameter of its Base for the Section of the greatest Circle of that Sphere; and if that Sphere revolves in a Circle, instead of viewing a Sphere, you will see a cylindrical or elliptical Ring; and whether this may not be the case of *Saturn*'s Ring, I leave to others to judge. A small Instance of the Truth of this, will appear from

from the boyish Performance of trundling a crooked Stick, one End of which is on fire, between your Fingers, in a dark Place. For while this is swiftly done, you will perceive an agreeable Curve of Fire. 7. The more oblique the Eye is to the Line or Plane which a distant Body moves in, the more will the apparent Motion differ from the true Motion. 8. So that if a Body revolves equably in the Circumference of the Circle A B F C E D, describing equal Arches in equal times, and the Eye be at O in the Plane of that Circle; it will, when



at the Point A, seem for some time to stand still, and constantly afterwards to move faster, till it gets to the Point F, where the Motion appears to become greatest; after which it appears to decrease, till the Body comes to C, where it will again seem to stand still; and then again, its apparent Motion will increase backwards, till the Body arrives at E, where it will seem again to move fastest; after which while it is going from E to A, it will appear to decrease.

If the Eye moves directly forwards from G to O, *&c.* any remote Object at rest at H, will appear to move the contrary way, *viz.* from H to I with the same Velocity the Eye moves. But if that Object moves the same way in the same Direction with the same Velocity that the Eye has, that Object will seem to stand still. If the Object has less Velocity than the Eye, the



Object will appear to go backwards, with a Velocity equal to the Difference of their Velocities. But if the Object has a greater, it will appear to go forwards with that Difference.

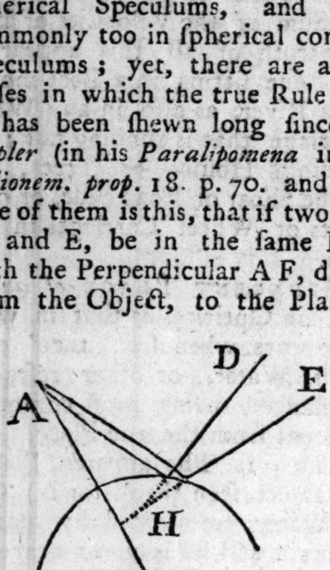
If an Object and the Eye move contrary ways in the same Direction with any Velocities, the Object will appear to go backward with the Sum of the Velocities of both. The truth of all this appears to any one sitting in a Boat moving in a River, as also in any Wheel-Carriage that is running fast; and viewing Houses or Trees, *&c.* on the Shoar or Road Side, or other Boats or Wheel Carriages in Motion.

Apparent Place *of an Object*, in Opticks, is that in which it appears when seen thro' or in Glass, Water, or other refracting Substances, being most commonly different from the true Place.

Thus, 1. The apparent Place of an Object seen thro' (or in) Glass or Water, terminated by parallel Planes, will be brought nearer to the Eye than its real Place. 2. If an Object be seen thro' a convex Glass, its apparent Place will be more remote from the Eye than its true place. 3. If an Object be seen thro'

thro' a concave Glass, its apparent Place will be brought nearer to the Eye than its true Place.

Apparent Place *of the Image of an Object*, in Catoptricks, is that where the Image of an Object made by the Reflexion of a Speculum appears to be in. The Ancients (as *Euclid*, in his *Catoptricks*; *Alhazen* and *Vitellio*, in their *Opticks*;) give it for a general Rule, that the apparent Place of the Image of an Object seen by Reflexion, is where the reflected Rays meet the Perpendicular drawn from the Object to the Plane of the Speculum, (so that if the Speculum be a Plane, the apparent Place of the Image will be at the same Distance behind the Speculum as the Eye is before it; if convex, it will appear behind the Glass nearer to the same; but if concave, it will appear before the Speculum:) Tho' they lay down this Rule as general, and indeed is universally true in plain and convex spherical Speculums, and most commonly too in spherical concave Speculums; yet, there are a few Cases in which the true Rule fails, as has been shewn long since by *Kepler* (in his *Paralipomena* in *Vitellionem. prop.* 18. p. 70. and fol.) One of them is this, that if two Eyes D and E, be in the same Plane with the Perpendicular A F, drawn from the Object, to the Plane of



the Speculum, the Place of the Image will appear to be at H on this Side the said Perpendicular. Moreover, if both Eyes or different Parts of the same Pupil, be in different Planes of Reflexion, the Image of the Object will mostly appear in the Concurrence of the reflected Rays, with the Perpendicular drawn from the Object to the Plane of the Speculum; yet sometimes it will appear without that Perpendicular, *viz.* when the Eye is very near to the Speculum, and the Object be removed from it beyond the Centre. Add to this, that if an Object be placed in the Focus, it cannot be seen at all. (See *Wolfius*'s *Catoptr.* §. 51. 188. 233, 234.)

The Doctrine of the apparent Places of the Images of Objects in spherical Speculums, as well convex as concave, is not quite perfect; for because different Planes of Reflexion cannot be conveniently delineated in the same Plane; neither can it be easily demonstrated which of the Rays proceeding from the same Point in the Speculum, and reflected to different Parts of the Pupil, meet; it has been hitherto thought fit to lay it down as a Maxim, satisfying most Phenomena, that the apparent Place of the Image, is where the reflected Rays meet with the Perpendicular drawn from the Object to the Plane of the Speculum. In cylindrical and conical Speculums, it is found, by Experience, that the Image is not far from the Surface; but what Lines are there intersected, where the Image appears, is not yet determined; no more than in Speculums of other Shapes, where the Loci of the Images have not yet been geometrically determined.

Apparent *Place of a Planet*, in Astronomy, is that Point upon the Surface of the Sphere of the World, whereat we see the Centre of the Sun, Moon or Stars, from the Surface of the Earth.

Applicate, is a Right-Line, otherwise called an *Ordinate* or *Semi-Ordinate*. Which see.

Ap-

APPLICATION, is ſometimes the geometrical Term for Diviſion; but Application alſo ſignifies the fitting or applying one Quantity to another, whoſe *Areas*, but not Figures, are the ſame. Thus *Euclid, lib.* 6. *prop.* 28. ſhews how to apply a Parallelogram to a Right-Line given, that ſhall be equal to a Right-lin'd Figure given.

APPLY. This Word is uſed three Ways.

1. It ſignifies to transfer a Line given into a Circle, (moſt uſually,) or into any other Figure; ſo that its Ends ſhall be in the Perimeter of the Figure.

2. It is alſo uſed to expreſs Diviſion in Geometry, eſpecially by the *Latin* Writers, who as they ſay *duc* A B *in* C B, (draw A B into C B,) when they would have A B multiply'd by C B, or (rather) have a Right-angled Parallelogram made of thoſe Lines. So they ſay *applica* A B *ad* C B, (apply A B to C B,) when they would have C B divided by A B; which is thus expreſs'd $\frac{CB}{AB}$.

3. It ſignifies alſo to fit Quantities, whoſe Area's are equal, but Figures different; as, when *Euclid*, in his ſixth Book, ſhews how on a Line given to apply a Parallelogram, equal to a Right-lin'd Figure given.

APPROACHES, in Fortification, are Works caſt up on both Sides; ſo call'd, becauſe the Beſiegers, by that means, may draw near a Fortreſs, without fear of being diſcovered by the Enemy. Or *Approaches* are all Sorts of Advantages, by the Help of which an Advancement may be made towards a Place beſieg'd.

APPROXIMATION, in Arithmetick, or Algebra, is a continual Coming ſtill nearer and nearer to the Root or Quantity ſought, without expecting to have it exactly. There are ſeveral Methods of Approximation laid down by Dr. *Wallis*, Mr. *Ralphſon*, Dr. *Halley*, *Ward*, &c. and they are all nothing but a Series infinitely converging or approaching ſtill nearer to the Quantity ſought, according to the Nature of the Series.

If there be any Non-Quadrat or Non-Cubick Number, the former being expreſs'd by $aa+b$. and the latter by $aaa+b$, where aa and aaa are the greateſt Square and Cube in the propoſed Numbers, then will

$$\sqrt{aa+b} = a + \frac{ab}{2aa+\frac{1}{2}b.} \text{ and}$$

$$\sqrt[3]{a^3+b} = a + \frac{ab}{3aaa+b.} = \frac{1}{2}a + \sqrt{\frac{1}{4}aa + \frac{b}{3a}} \text{ nearly.}$$

Theſe will be eaſy and expeditious Approximations to the Square and Cube Root.

APRON, is a Piece of Lead that wraps over, or covers the Vent or Touch-Hole of a Piece of Ordnance.

APSIS, is uſed as well for the higheſt Part of an Orbit, to which when a Planet comes, it is at the greateſt Diſtance from the Sun, as the loweſt Part of that Orbit, when the Planet is in its neareſt Diſtance to the Sun.

The Line of the *Apſis* or *Apſides*, is a Line drawn from the Aphelium to the Perihelium.

AQUARIUS, a Conſtellation in the Heavens, being the eleventh Sign in the Zodiack, and is commonly mark'd with this Character ♒, and conſiſts of thirty three Stars.

AQUEDUCT, is a Conduit of Water, and ſignifies an artificial Canal, either running under ground, or rais'd above it, and ſerving to convey Water from one Place to another according to their Level,

notwithstanding the Unevenness of the intermediate Ground. The *Romans* built several very considerable ones in their City: And *Julius Frontinus*, who had the Direction of them, tells us of nine which discharg'd themselves thro' 1314 Pipes of an Inch Diameter; and *Blasius upon Livy* observes, that these Aqueducts brought into *Rome* above 500000 Hogsheads of Water, in the Space of twenty-four Hours.

AQUEOUS HUMOUR, or the watry Humour of the Eye, is the utmost, being transparent, and of no Colour; it fills up the Space that lies between the Cornea Tunica and the Crystalline Humour.

AQUILA, or VULTUR VOLANS, a Constellation in the Northern Hemisphere, consisting of thirty-two Stars.

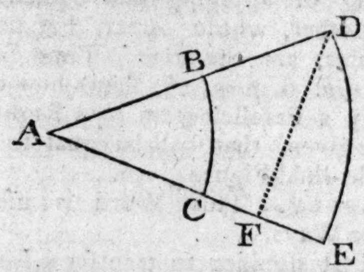
ARA, the *Altar*, a Southern Constellation containing eight Stars.

ARACHNOIDES, is the Crystalline Tunic of the Eye; by some called also *Aranea Tunica*, or *Crystallina*, and is that which surrounds and contains the Crystalline Humour; by reason of its light thin Contexture, like that of the Web of a Spider, it has the Name of *Aranea*. This Coat, by means of the Ciliary Processes, helps to move the Crystalline Humours of the Eye nearer to, or further from, the Retina, and perhaps also to render its Figure more or less Convex.

ARCH, or ARC, in general is any part of a Curve Line; but it is more usually taken for any Part of the Circumference of a Circle.

ARCS (EQUAL) *of the same Circle*, are such that contain the same Number of Degrees.

ARCS (SIMILAR;) if the Arc BC does contain the same Number of Degrees as the Arc DE; or if the Radius AB is to the Radius AD, as the Arc BC is to the Arc DE, then the Arcs BC and DE are similar. If the Radius



AD of any Arch DE be suppos'd 1, and the Sine DF thereof be call'd y, then the Length of the Arch DE will be express'd by this infinite Series;

$$y^7+\frac{1}{2\times3}y^3+\frac{1\times3}{2\times4\times5}y^5+\frac{1\times3\times5}{2\times4\times6\times7}y+\frac{1\times3\times5\times79}{2\times4\times6\times8\times9}y^9 \text{ \&c.}$$

And if the first Term of this Series be called A, the second B, the third C, the fourth D, &c. and the second be multiply'd by $\frac{1}{2}$, the third by $\frac{3}{3}$, the fourth by $\frac{5}{5}$, &c. then that Series will become this:

$$y^7+\frac{1}{2\times3}+Ay^2+\frac{3}{4\times5}+3By^2+\frac{5}{6\times7}+yCy^2+\frac{7}{8\times9}+7Dy^2+\frac{9}{10\times11} \text{ \&c.}$$

ARCHES, in Architecture, are Parts of the inward Support of any Superstructure, and they are either circular, elliptical, or streight, (as the Work-men improperly call them.)

ARCHES (ELLIPTICK,) were formerly much used instead of Mantle-trees in Chimneys: They had a Key-Stone, and Chaptrels, or Imposts, and consisted of two Haunses and a Scheme.

ARCHES (GOTHICK,) are such as are used in Gothick Buildings, call'd by the *Italians Di terzo &*

di

di quarto acuto, or of third and fourth Point, because they consist of two Arches of a Circle, meeting in an Angle at the Top, and drawn from the Division of a Chord into three, four or more Parts, at pleasure.

Arch'd (Skene, Scheme,) is a flat Arch, less than a semicircular one.

Arches (Streight,) as the Workmen improperly call them, which are used over Windows and Doors, *&c.* have plain streight Edges both upper and under, which are parallel, but both the Ends and Joints do all point towards a certain Centre. They are now usually about a Brick and a half thick; which, when rubb'd, is about twelve Inches. The levelling End of this Arch is called the Skew-Back; and the several Joints between the Courses of Bricks in the Arch, the Workmen call the Sommering.

Archipelagus, in Geography, is a Part of the Sea, containing many small Islands one near another, and consequently many little Seas denominated from those Islands; as, the *Grecian Archipelago*, or *Ægean Sea*.

Architect, is one that understands Architecture, which is the Art or Science of well Building, that is, of conceiving an Idea of an Edifice in the Mind, and building it according to the same, so as to answer the End of the Builder; and is divided into Civil, Military, and Naval.

Architecture (Civil,) teaches how to make any Kinds of Buildings; as Palaces, Churches, or private Houses.

The most ancient Writer of Architecture extant, is *Vitruvius*, who lived in the Reign of *Augustus* the *Roman* Emperor, to whom he dedicated his ten Books on that Subject; and since him the Writers on Architecture are numerous. Some of them are, *Philander, Barbarus, Salmasius, Baldus, Leo Baptista Albertus, Gauricus, Demoniosius, Perrault, De l'Orme, Rivius,* Sir *Henry Wotton, Serlio, Palladio, Strada, Vignola, Scamozzi, Dieussart, Catanei, Freard, De Chambray, Blondel, Goldman, Sturmy, Dominicus de Rosi, Desgodetz, Baratteri, Mayer, Gulielmus.* These three last treating of Water-Architecture. To which may be added an anonymous *French* Treatise concerning the making of Rivers Navigable.

Architecture (Military) instructs us in the best Ways of fortifying Cities, Camps, Sea-Ports, or any other Places of Strength. And,

Architecture (Naval,) is the building of Ships.

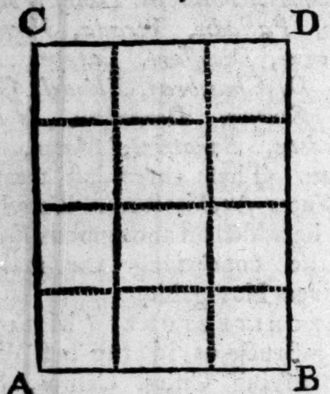
Architrave is the principal Beam, or Poitrail in any Building, and the first Member of the Entablement, being that which bears upon the Column, and is made sometimes of a single Summer, as appears in most of the ancient Buildings, and sometimes of several Haunses, as is usual in the Works of the Moderns. It is call'd the *Reason-Piece* or *Master-Beam*, in Timber Buildings; but in Chimneys it is called the *Mantlepiece*; and over the Jaumbs of Doors, and Lintels of Windows, *Hyperthyron*.

Arctick Circle, is a lesser Circle of the Sphere, or Globe, parallel to the Equator, and 23° 30'. from the North Pole of the World, from whence it takes its Name. This, and the Antarctick Circle, which is one parallel to the Equator, and at the same Distance from the South Pole, are call'd the two Polar Circles.

Arctophylax. See *Boötes*.

Arcturus: A fix'd Star of the first Magnitude, placed in the Skirt of *Arctophylax*.

AREA, of any superficial Figure, n Geometry, is the internal Capacity or Space contain'd within the Lines or Line bounding it in the square Parts of any Measure; as,



suppose the Side A B of the Parallelogram A B C D to be three Inches, or three Foot, or three Yards, *&c.* and the Side A C to be four Inches, or four Foot, or four Yards, *&c.* then the Area or superficial Capacity of the said Parallelogram will be twelve Inches, or twelve Foot, or twelve Yards, or will contain twelve little equal Squares, each of whose Sides is one Inch, or one Foot, or one Yard.

For the Areas of Figures, see under their respective Names.

AREOMETER, is an Instrument to measure the Gravity of Liquors; and it is usually made of a thin fine glass Ball, with a long taper Neck, seal'd at the top, there being first as much running Mercury put into it as will serve to keep it swimming in an exact Posture. The Stem, or Neck, is divided into Parts, which are number'd, that so by the depth of its Descent into any Liquor, its Lightness may be known by those Divisions: for that Fluid or Liquor in which it sinks least, must be heaviest; and that in which it sinks most, will be lightest

There is another newer Instrument of this kind described by Mr. *Homberg* of *Paris* in the Memoirs of the *French* Academy for the Year 1699.

AREOSTYLE, in Architecture, is a sort of Edifice where the Pillars are set at a great distance from one another.

ARGO NAVIS, a Southern Constellation, consisting of forty-two Stars.

ARGUMENT *of Inclination,* is an Arc of an Orbit, intercepted between the Node ascending, and the Place of the Planet from the Sun, being number'd according to the Succession of Signs.

ARGUMENT *of the Moon's Latitude,* is her Distance from the Node.

ARIES, a Constellation of Stars drawn on the Globe in the Figure of a Ram. It is the first of the twelve Signs of the *Zodiack,* and mark'd thus ♈, and consists of nineteen Stars.

ARITHMETICK, is the Art or Science of Numbers.

Proclus, in his Commentary upon the first Book of *Euclid,* says, that the *Phœnicians,* by reason of their Traffick and Commerce, were thought to be the first Inventors of Arithmetick. Which *Pythagoras* and his Followers, as also the *Egyptians, Greeks,* and *Arabians* afterwards much improved; as *Clavius* and others tell us. But if we are to judge of the Knowledge of those Antients in Arithmetick from their Writings upon the Subject, which have been transmitted to us, we may safely conclude, that their Advances herein were but very short and scanty. For setting aside *Euclid,* who indeed has given several very plain and pretty Properties of Numbers in his *Elements,* and *Archimedes* in his *Arenar.* they mostly consist in dry disagreeable Distinctions and Divisions of Numbers: as may be seen, in some sort, in *Nichomachus*'s and *Boetius*'s Arithmetick. Nor is the

Greek Manner of Numeration, by the Letters of the Alphabet, at all fit for the Performance of the practical Parts of Multiplication, Division, *&c.* with the Ease and Expedition that they are now-a-days performed by the *Indian* Figures, or nine Digits.

Dr. *Wallis*, in his *History of Algebra*, says, that there are at *Oxford* two Arithmetical Manuscripts of *Johannes de Sacro Bosco*, who died about the Year 1250, wherein the Operations of Addition, Subtraction, Multiplication, Division, and Extraction of the square and cube Roots are performed much the same as now.

Boetius's Arithmetick was wrote in the sixth Century. And in the ninth Century, *Psellius* wrote a Compendium of the ancient Arithmetick in *Greek*, translated into *Latin* by *Xylander*, and published *anno* 1556, at *Basil*. Such a Compendium too was published by *Willichius*, *an.* 1540. Other Writers are *Jordan*, (whose Arithmetick was published *an.* 1480,) *Barlaam* the Monk, *Frater Lucas de Burgo*, *Stifel*, *Nicholas Tartaglia*, *Maurolycus*, *Henischius*, *Andrea Tacquet*, *Clavius*, *Leotaude*, *Wells*, *Metius*, *Gemma Frisius*, *Wingate*, *Kersey*, *Bayer*, *Hatton*, *Cunn* (of *Fractions*,) *Weston*, with a Multitude of others, too many to set down here. But the best and most absolute Work of this kind, both as to Matter, Order, Clearness of Expression, and even Language, is the *System of Arithmetick*, published in our Language a few Years ago, at *London*, by the very ingenious Mr. *Malcolm*.

ARITHMETICK (BINARY,) is that wherein only Unity, or 1 and 0 are used. This was devised by Mr. *Leibnitz*, (see *Miscellanea Berolin.* p. 336, *& seq.*) who shews it to be apt for discovering the Properties of Numbers; and Mr. *Dangicourt*, in the *History of the Royal Academy of Sciences for the Year* 1703, p. 105. gives us a Specimen thereof about Arithmetical Progressionals; where he shews, that because in Binary Arithmetick only two Characters are used, therefore the Laws of Progression may be the easiest of all discover'd by it.

ARITHMETICK (COMMON.) This signifies the practical Rules of Addition, Subtraction, Multiplication, Division, *&c.* of Numbers, and Decimal Fractions.

ARITHMETICK (DECADAL,) is the Arithmetick which we use by the nine Figures and a Cypher, which is commonly attributed to be the Invention of the *Arabians*, and was, no doubt, taken from the Number of our Fingers, which is ten; because, in Computations, we use the Fingers before we understand Arithmetick.

ARITHMETICK (DECIMAL,) is the Doctrine of decimal Fractions.

ARITHMETICK (INSTRUMENTAL,) is the Performance of the Rules of Common Arithmetick by Instruments.

ARITHMETICK (LOGARITHMETICAL,) is the Doctrine of Logarithms.

ARITHMETICK (POLITICAL,) is the Application of Arithmetick to Politicks.

ARITHMETICK (SEXAGESIMAL) is the Doctrine of Sexagesimal Fractions.

ARITHMETICK (SPECIOUS) is the same as Algebra.

ARITHMETICK (TETRACTYCAL,) is that wherein only 1, 2, 3, and 0 are used.

There is a Treatise of this Arithmetick written by Mr. *Eckard Weigel*, a *German*. But both Binary Arithmetick and this are useless Curiosities, especially with regard to the practical Part, since the Decadal Arithmetick is received by all Na-

tions, and ingrafted in us while Children, and since the Trouble of learning a new Numeration will not be ballanc'd by the Advantage gain'd from it; and lastly, because Numbers may be vastly more compendiously expres'd by Decadal Arithmetick, than by either of these.

ARITHMETICK (THEORETICAL,) is the Knowledge or Science of the Properties of Numbers.

ARITHMETICK *of Infinites*, is the Method of summing up a Series, or Row of Numbers, consisting of infinite Terms, or of finding the Ratio's of them.

This Method was first invented by Dr. *Wallis*, as may be seen in his *Opera Mathematica*, vol. I. where he shews the Use of it in Geometry, in finding the Area's of Superficies, and the Contents of Solids, and their Proportions. But the Method of Fluxions, which is a universal Arithmetick of Infinites, performs these things much easier, and a Multitude of Things can be perform'd by the latter, that the former will not touch.

ARITHMETICAL COMPLEMENT *of a Logarithm*, is what that Logarithm wants of 10000000; as the Arithmetical Complement of the Logarithm 8.154032 is 1.845968; where every Figure, but the last 8, is taken from 9, and that from 10.

ARITHMETICAL PROPORTION, or PROGRESSION, is when Numbers, or other Quantities, do proceed by equal Differences, either increasing or decreasing; as 2, 4, 6, 8, 10, *&c.* or a, $2a$, $4a$, $6a$, *&c.* or 5, 4, 3, 2, 1, or $5a$, $4a$, $3a$, $2a$, a; where the two former Series are increasing, and the two latter decreasing, the common Difference in those being 2, and in these 1. Here follows some Properties of Arithmetical Progressionals.

1. If there are three Quantities in Arithmetical Progression, the Sum of the Extremes is equal to the Double of the Mean; as 2, 4, 6, are so; whence $2+6=2\times4$.

2. If there be four Quantities in continual Arithmetical Proportion, the Sum of the Extremes is equal to the Sum of the Means; as 2, 4, 6, 8, are so: whence $2+8=4+6$.

3. If never so many Quantities are in an Arithmetical Progression, the Sum of the Extremes is always equal to the Sum of any two Means equally distant from the Extremes, or to the Double of the middle Term, if the Number of Terms be odd; as suppose 2, 4, 6, 8, 10, 12, be an even Number of Terms, then $2+12=4+10=6+8$; and if 2, 4, 6, 8, 10, be an odd Number, then $2+10=2\times6$.

4. The Sum of any Number of Terms of an Arithmetical Progression, is equal to the Sum of the Extremes multiplied by half the Number of Terms, or half that Sum multiplied by the whole Number of Terms; as the Sum of all the Terms in the last Progression is $=\overline{2+10}\times2\frac{1}{2}$ or $=5\times\frac{2+10}{2}=30$.

5. The Ratio of the Sum of an Arithmetical Progression, whether finite or infinite, whose first Term is 0, is to the Sum of as many Terms equal to the greatest; as 1 to 2.

6. The Ratio of the Sum of the Squares of every Term of an Arithmetical Progression, beginning at 0, and continued to Infinity, is as 1 to 3.

7. The Ratio of the Sum of the Cubes of such a Progression, is to the Sum of as many Terms, equal to the greatest; as 1 to 4.

8. And universally, if m be the Power that every Term of such a Progression is raised to, the Sum of all those Powers will be to as many Terms equal to the greatest; as 1 to $m+1$.

All these Theorems, but the last, are

are demonſtrated by *Sturmy*, in his *Matheſis Enucleata*.

Arithmetical Instruments, are Inſtruments to perform Arithmetical Operations with; ſuch as *Napier*'s-Bones, and Sliding Rules, *&c.*

Arithmetical Mean, is the middle Term of three Quantities in Arithmetical Progreſſion.

Ark, the ſame as *Arch.* Which ſee.

Ark *of Direction* or *Progreſſion*, in Aſtronomy, is that Arch of the Zodiack that a Planet appears to deſcribe, when its Motion is progreſſive according to the Order of the Signs.

In the *Ptolemaick* Syſtem, it is the Ark of the Epicycle, which a Planet deſcribes when it is progreſſive according to the Order of the Signs.

Ark *of Retrogradation*, is that which a Planet deſcribes when it is retrograde, or moves contrary to the Order of the Signs.

Ark *of the firſt and ſecond Station*, is the Ark that a Planet deſcribes in the former or latter Semi-circumference of its Epicycle, when it appears ſtationary.

Arm'd. A Loadſtone is ſaid to be armed, when it is capp'd, caſed, or ſet in Iron or Steel, in order to make it take up a greater Weight, and alſo to diſtinguiſh its Poles readily.

The Armour of a Loadſtone, in figure of a Right-angled Parallelopipedon, conſiſts of two thin Pieces of Steel or Iron, in figure of a Square, having a Thickneſs proportional to the Goodneſs of the Stone; for if a weak Stone has a ſtrong Armour, it will produce no Effect; and if the Armour of a ſtrong Loadſtone be too thin, it will not produce ſuch an Effect as when thicker: A convenient Thickneſs for the Armour is found by filing it thinner and thinner, until you find its Effect to be the greateſt poſſible. The Armour of a Spherical Loadſtone conſiſts of two Steel Shells faſten'd to one another by a Joint, and muſt cover a good Part of the Convexity of the Stone. This muſt be alſo filed away by degrees, until the Effect of the Loadſtone is found to be the greateſt poſſible.

It is very wonderful that the Armour of a Loadſtone will ſo much augment its Effect, that good Stones after they are arm'd, will lift up above 150 Times more than before.

There are indifferent good Loadſtones, which when unarmed weigh about three Ounces; but when arm'd, will lift up more than ſeven Pounds.

Armillary Sphere, is when the greater and leſſer Circles of the Sphere, being made of Braſs, Wood, Paſtboard, *&c.* are put together in their natural Order, and plac'd in a Frame, ſo as to repreſent the true Poſition and Motion of thoſe Circles.

Artificial Day, being the ſame as the Natural Day, is that Space of Time elapſed from the Riſing of the Sun to the Setting thereof; whence the Length of the Artificial Day, of thoſe inhabiting under the Equinoctial will always be twelve Hours; and to thoſe that are nearer the Poles, the Artificial Day is ſo much the longer: ſo that the length of the Artificial Day to thoſe under the Poles, (if there be any People there,) will be half a Year.

Artificial *Numbers*, *Sines*, and *Tangents*, are the Logarithms of the Natural Numbers, Sines, and Tangents.

Ascending Node, is that Point from whence a Planet runs Northward beyond the Ecliptick.

Ascensional Difference, is the Difference between the Right and Oblique Aſcenſion of any Point in the Heavens; or it is the Space of Time the Sun riſes or ſets before or after ſix o'Clock; as Co-T. Lat : T. ☉ Decl. : : R : S. of Aſcenſional Difference.

ASCENSION (OBLIQUE,) is that Degree and Minute of the Equinoctial, reckoning from the Beginning of *Aries*, which rises with the Centre of the Sun, or a Star, or which comes to the Horizon at the same time as the Sun, or a Star, in an Oblique Sphere.

ASCENSION (RIGHT) *of the Sun, or a Star,* is that Degree of the Equinoctial, accounted from the Beginning of *Aries,* which rises with it in a Right Sphere. R : Co-S, ☉'s greatest Decl. :: T. Dist. from ♈ or ♎ : T. Right Ascension.

ASCII are the Inhabitants of the Torrid Zone, which twice a Year have the Sun (at Noon) in their Zenith, and consequently then their Bodies cast no Shadow. Whence comes the Name of *Ascii*.

ASPECT, is the Situation of the Planets and Stars, in respect of one another. Of these they commonly reckon five different Sorts.

1. SEXTILE, is when two Planets, or Stars, are sixty Degrees from one another.

2. QUARTILE, when they are ninety Degrees distant from one another.

3 TRINE, when they are distant 120 Degrees.

4. OPPOSITION, when they are 180 distant.

5. CONJUNCTION, when they are both in the same Degree.

Kepler added eight new Aspects to these, *viz.* the Demi-sextile of 30°, the Decile of 36°, the Octile of 45°, the Quintile of 72°, the Tredecile of 108°, the Sesquatile of 135°, the Biquintile of 144°, and the Quincunx of 150.

All these different Positions of the Planets are reckon'd in the Ecliptick by the secondary Circles drawn thro' the Centres of the Planets; that is, if the secondary Circles, drawn thro' the Centres of two Planets, cut the Ecliptick in two Points, that are sixty Degrees distant from one another, then those Planets are said to be in a Sextile Aspect. Understand the same in others.

ASTERISM; the same with *Constellation*, or a Collection of many Stars into one Class, or System, which is usually on the Globe represented by some one particular Image, or Figure, to distinguish the Stars that compose this Constellation from those of others.

ASTRAGAL, *from* Astragalos *in* Greek, *the Bone of the Heel*, is a little round Moulding, which encompasses the Top of the first, or Shaft of a Column, and differs only from the Torus in Bigness, its Height being 1 ½ Module, and 3 Min.

ASTROLABE. The Name of a plain Sphere, or Stereographick Projection of the Sphere, either upon the Plane of the Equinoctial, the Eye being supposed in the Pole of the World, or upon the Plane of the Meridian, when the Eye is supposed in the Point of Intersection of the Equinoctial and Horizon. *Stoffler*, *Gemma Frisius*, and *Clavius* have treated of this Projection.

ASTROLABE (SEA,) is an Instrument for taking the Altitude of the Sun or Stars, at Sea; being a large brass Ring of about 15 Inches in Diameter, whose Limb, or a convenient Part thereof, is divided into Degrees and Minutes, with a moveable Index or Label, which turns upon the Centre, and carries two Sights. At the Zenith is a Ring, to hang it by in time of Observation, when you need only turn it to the Sun, that the Rays may pass freely thro' both the Sights, and the Edge of the Label cuts the Altitude in the Limb. This Instrument, if well made, (tho' not now much in use,) is as good, if not better than any of the other Instruments

ments that are uſed for taking the Altitude at Sea; eſpecially for taking of Altitudes between the Tropicks, when the Sun comes near to the Zenith.

ASTROLOGY, is an Art that pretends to foretel future Things from the Motion of the heavenly Bodies, and their Aſpects to one another, and from imaginary Qualities that are ſuppoſed to be in the Planets and Stars affecting Mortals here below. But as there is nothing of Truth in this Art, as all diſcerning People in this Age are very well ſatisfy'd of; therefore it will be to little or no purpoſe to explain the Terms of it.

ASTRONOMICAL KALENDER, is an Inſtrument engraved upon Copper-plates, printed on Paper, and paſted on Board, with a Braſs Slider, which carries a Hair, and ſhews, by Inſpection, the Sun's Meridian Altitude, Right Aſcenſion, Declination, Riſing, Setting, Amplitude, *&c.* to a greater Exactneſs than our common Globes will ſhew.

ASTRONOMICAL HOURS, are the equal Hours: Whereof there are 24 accounted from the Noon of one natural Day, (or, as ſome will have it, from Midnight) to the Noon or Midnight of the next natural Day.

ASTRONOMICAL QUADRANT, is a large Quadrant made all of Braſs, or of Wooden Bars, uſually faced with Plates of Iron, having its Limb divided into Degrees and Minutes, and even Seconds if poſſible, with plain Sights fix'd to one Side of it, or inſtead thereof a Teleſcope, and an Index moving about the Centre, carrying either plain Sights, or a Teleſcope.

Theſe Quadrants are uſed in taking Obſervations of the Sun, Planets, or fix'd Stars. The Ancients uſed only plain Sights; but the Moderns have found it of vaſt Benefit to uſe Teleſcopes inſtead of them. And the Contrivance well known to our Inſtrument-Makers, of moving the Index, by help of a Screw on the Edge of the Limb, and of readily and eaſily directing it, and the Quadrant upon its Pedeſtal, to any deſir'd Phænomena by means of Screws and dentated Wheels, is a ſtill greater Improvement of this Inſtrument.

Tycho Brahe was the firſt that uſed a tolerable *Apparatus* of Aſtronomical Inſtruments, which are deſcrib'd in his *Aſtronomia Inſtaurat. Mechanica*, printed in the Year 1602. But *Hevelius*'s *Apparatus* deſcrib'd in his *Machina Cæleſtis, A. D.* 1673. are abundantly more ſumptuous, and better contriv'd than *Tycho Brahe*'s. Yet theſe, one ſhould think, could not perform Obſervations ſo exact, as if he had uſed Teleſcopick Sights; for he would not uſe them. And that occaſion'd Dr. *Hooke* to write *Animadverſions upon* Hevelius'*s Inſtruments*, printed in the Year 1674, wherein he deſpiſes them on account of their Inaccuracy. But Dr. *Halley*, at the Deſire of the *Royal Society*, went over to *Dantzick* in the Year 1679, to inſpect his Inſtruments, and did approve of the Accuracy of them, and of his Obſervations with them.

ASTRONOMY. The Knowledge of the Motions, Times, and Cauſes of the Motions, Diſtances, Magnitudes, Gravities, Light, *&c.* of the Celeſtial Bodies, *viz.* the Sun, Moon and Stars; explaining the Cauſes and Nature of the Eclipſes of the Sun, and Moon; the Conjunctions and Oppoſitions of the Planets, and any other of their mutual Aſpects, with the time when any of them did or will happen.

ASTRONOMY (SPHERICAL,) is the Conſideration of the Univerſe, as it offers it ſelf to our Sight.

ASTRONOMY (THEORETICAL) is the Conſideration of the true Structure

Structure of the Universe; and from thence the Determination of the Appearances thereof.

Astronomy is very ancient, as we may learn from *Porphyry*, and *Simplicius* in his Comment upon *Aristotle*'s 2d Book *de Cœlo*, who say, that when *Alexander* the *Great* took *Babylon*, *Callisthenes*, one of *Aristotle*'s Scholars, by the Desire of *Aristotle*, carried from thence to *Greece*, Celestial Observations made by the ancient *Chaldeans* and *Babylonians*, of two thousand Years standing. And Sir *Henry Savil* towards the latter Part of his 2d Lecture upon *Euclid*, speaking of this, says that altho' the common printed Edition of *Simplicius* mentions but two thousand Years; yet in his Manuscript it is thirty-one thousand Years; and *Cicero*, in *lib.* 1. *de Divinatione*, forty-seven thousand Years.

Some of the astronomical Writers, are *Ptolemy*, who has preserved the Observations of the Ancients, amongst which are those chiefly of *Hipparchus*, in his *Almagest*.—*Albategnius*, who has given the Observations of the *Saracens*,—*Sacro Bosco*, —*RegioMontanus*, —*Purbachius*, —*Copernicus*, —*Tycho de Brahe*,—*Lansbergius*,—*Longomontanus*,—*Clavius*, —*Kepler*, —*Gallilæo*, —*Bayer*, —*Hevelius*,—Dr. *Hook*,—*Ricciolus*, — *Horrocs*, — Sir *Jonas Moor*, — Mr. *Huygens*,—*Tacquet*,—*Flamstead*, —*Bullialdus*,—*Seth Ward*,—Count *Pagan*,—*Wing*, —*Street*, —Mr. *De la Hire*,—*Newton*,—*Gregory*,—*Mercator*,—*Whiston*,—Dr. *Halley*, —*Du Hamel*,— Dr. *Keil*, — the two *Cassini's*, both Father and Son.—Mr. *Leadbetter*. —Mr. *Brent*, &c.

We learn from *Ptolemy*, that *Tymocaris*, and *Arystillus* left several Observations of the fix'd Stars about 120 Years before Christ. But the Astronomy of the Ancients was very defective upon account of their bad Instruments, and their Want of the Knowledge of the Telescope, and the Use of the Micrometer, and the false System of the World that they so strenuously adhered to, till *Copernicus* having revived the true *Pythagorean* System about the Year 1556, *in Libro de Revolutione Cœlestium*, and afterwards *Kepler*, from the Observations of *Tycho Brahe*, (in his *Comment on the Motions of Mars*, printed in the Year 1609,) having found out the Laws of the Motions of the Planets, Astronomy then began to gain ground, and shine in its true Lustre; and at length, by the Labours of several ingenious Persons, (most our own Countrymen) especially Sir *Isaac Newton*, it is now arrived, perhaps, to the greatest Perfection that Mortals will be ever able to bring it.

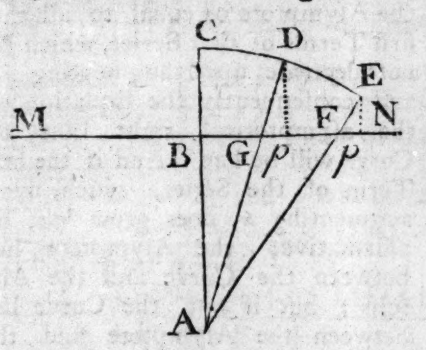
Asymptotes, are properly straight Lines, that approach nearer and nearer to the Curve they are said to be the Asymptotes of; but if they, and their Curve, are indefinitely continued, they will never meet: Or Asymptotes are Tangents to their Curves at an infinite Distance. And two Curves are said also to be Asymptotical, when they continually approach to one another; and if indefinitely continu'd, do not meet: As two Parabola's, that have their Axes placed in the same straight Line, are Asymptotical to one another.

Of Curves of the first kind, that is, the Conick Sections, only the Hyperbola has Asymptotes, being two in Number.

All Curves of the second kind have at least one Asymptote; but they may have three: And all Curves of the fourth kind may have four Asymptotes. The Conchoid, Cissoid, and Logarithmick Curve have each one Asymptote.

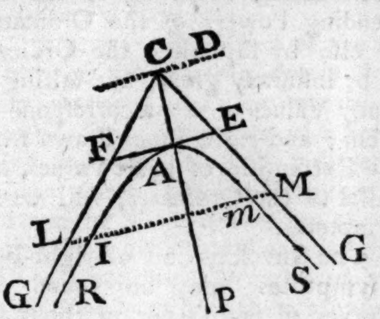
The Nature of an Asymptote will be very easily conceiv'd from that of the Conchoid: For if CDE be

a Part of the Curve of the Conchoid, and A its Pole, and the right Line MN be so drawn, that the Parts BC, GD, FE, &c. of right Lines,



drawn from the Pole A, be equal to each other, then the Line MN will be the Asymptote of the Curve, because the Perpendicular D p is shorter than BC, and EP than D p, and so on; and the Points E, &c. and p can never coincide.

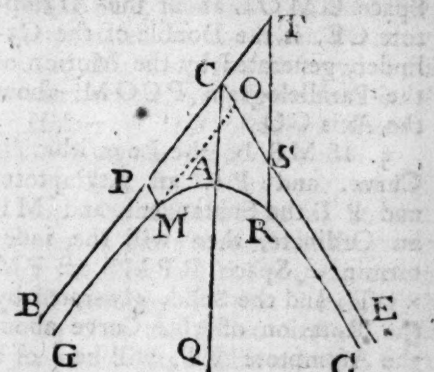
1. If CP be a Diameter of the Hyperbola RAS, and CD be the Semi-conjugate to it; and if the Line FE be a Tangent in the Point A, and AE$=$FA$=$CD; then, if the Lines CG, CG, be drawn from the Centre C thro' the Points E and



F, these Lines CG, CG, will be the Asymptotes of the *Hyperbola* RAS. And,

2. If any right Line LM be drawn parallel to the Tangent FE, (or even not parallel) to cut the Curve and the Asymptotes, then will the Parts L l, M m, be equal, and $Ll \times Ml = \overline{AE}^2$. And moreover, any Annulus, or Ring, made by M m, or L l, when the whole Figure revolves about the Diameter AP, will always be equal to a Circle, whose Diameter is AE.

3. Again, in the second Figure, if one of the Asymptotes be continu'd out to T, and the Line TSR be drawn parallel to the Dia-

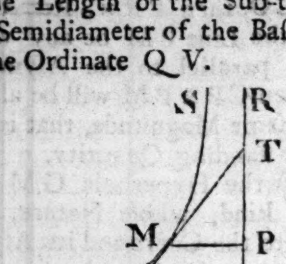


meter CO, then $TR \times SR = \overline{AC}^2$; and if the Line PM be any where drawn parallel to the Asymptote CS, then $CP \times PM$ will be always of the same Magnitude, that is, always a standing Quantity.

4. If the Hyperbola GMR be of any kind, whose Nature, with regard to the Curve and its Asymptote, is express'd by this general Equation $x^m y^n = a^{m+n}$, and the Right Line PM be drawn any where parallel to the Asymptote CS, and the Parallelogram PCOM be compleated, then this Parallelogram is to the hyperbolick Space PMGB, contain'd under the determinate Line PM, the Curve of the Hyperbola GM indefinitely continued towards G, and the Part PB of the Asymptote indefinitely continu'd the same way, as $m - n$ is to n; and so if m be greater than n, the said Space is squarable; but when $m = n$, as it will be in the common

common Hyperbola, the Ratio of the foregoing Parallelogram to that Space is as 0 to 1, that is, the said Space is infinitely greater than the Parallelogram, and so cannot be had; and when m is less than n, then that Parallelogram will be to that Space, as a negative Number to a positive one, and the said Space is squarable; and the Solid, generated by revolving the indeterminate Space GMOL about the Asymptote CE, is the Double of the Cylinder, generated by the Motion of the Parallelogram PCOM about the Axis CO.

5. If MS be the Logarithmick Curve, and PR an Asymptote, and PT the Subtangent, and MP an Ordinate, then will the indeterminate Space RPMS $=$ PM $\times$ PT; and the Solid, generated by the Rotation of this Curve about the Asymptote VP, will be $\frac{1}{2}$ of a Cylinder, whose Altitude is equal to the Length of the Sub-tangent, and Semidiameter of the Base equal to the Ordinate QV.



All Curves that have infinite Legs, have one or more Asymptotes, being either right Lines or Curves; and to find generally the Nature of the right Line or Curve, which is the Asymptote of a given Curve, by having the Equation of the Curve given: Let z be the Ordinate of the Asymptote, whether a right Line or Curve, then reduce the Value of the Ordinate y of the given Curve into an infinite Series, so as to converge the sooner, the greater the Abscis x is; that is, find the Value of y when x is infinite, which cannot be generally done without a Series, then will the Ordinate z of the Asymptote be equal to all the first Terms of that Series, which do not decrease upon augmenting x; and consequently the Equation of the asymptotical right Line or Curve will be had: And if the first Term of the Series, which, upon augmenting x, does grow less, be affirmative, the Asymptote lies between the Curve and the Abscis; but if not, the Curve lies between the Asymptote and the Abscis: for no Term of the Series becomes equal to that Part of the Ordinate intercepted between the Leg and its Asymptote, when x is infinitely great; and if several Values of the initial Terms of the Series coincide, several Asymptotes coincide: But when a Curve has right-lin'd Asymptotes, which are parallel to the Ordinates of that Curve, these cannot be determin'd by reducing the Value of y into a Series; but they may be found by reducing the Value of the Abscis into a Series, consisting of the descending Powers of the Ordinate; or else by supposing the Ordinate to be infinitely great, and taking as many Values of x as correspond to them; and right Lines drawn from the Extremities of those Values, parallel to the Ordinates, will be Asymptotes.

The Investigation of right-lin'd Asymptotes may be found for Curves of any Order, without having recourse to Series's, by means of the general Equation of that Order, thus: Let the Equation be $Ay^2 + Bxy + Cx^2 + Dy + Ex + F = 0$. Suppose $y = ax + b + cx^{-1}$, &c. then will $Aa^2 + Ba + C$ be $= 0$; and by extracting the Roots of this last Equation, we

we ſhall have a, and b will be $= -\frac{Da + E}{2aA + B}$, and $c =$ $\frac{Ab^2 + Db + F}{2Aa + B}$; and if the Equation be $Ay^3 + Bxy^2 + Cx^2y + Dx^3 + Ey^2 + Fxy + Gx^2 + Hy + Kx + L = 0$, the Roots of this Equation $Aa^3 + Ba^2 + Ca + D = 0$. will give a, and b will be $=$ $\frac{Aa^2 + Ba + C}{3Ea^2 + 2Fa + C}$, and $c =$ $\frac{-3Ab^2 + Bb^2 + Eab + Fb + Ha + K}{3Aa^2 + 2Ba + C}$.

Where a is the Inclination of the Aſymptote to the Abſciſs, b is the Diſtance between the Beginning of the Abſciſs; and the Point in which the Aſymptote cuts the ſame, and c ſhews on which ſides of the Aſymptotes the Legs of the Curve lie.

Right-lin'd Aſymptotes may be conſider'd as Tangents to Points of the Curve infinitely diſtant; ſo that the Doctrine of Aſymptotes may be reduced to that of Tangents.

Atmosphere, is all the Air, that the Earth is encompaſs'd with, conſider'd together.

A very ſenſible Effect of the Preſſure of the Atmoſphere is ſhewn, by drawing the Air out of two equal Braſs Segments of a Sphere, whoſe Brims are well poliſhed, of about three Inches in Diameter; for when the Air is drawn out of them after they are apply'd to each other, it will require a Weight of about 140 Pounds to pull them aſunder.

That the Moon has an Atmoſphere, may be gather'd from ſeveral Obſervations made by Aſtronomers.

1. Mr. *Wolf*, in the *Acta Eruditorum*, for the Year 1706, p. 385. ſays, That at the Time of the great Eclipſe of the Sun, *May* the 1ſt, 1706, he obſerved a lucid Ring about the Moon, parallel to her Limb, which he could very well perceive not to be a lucid Part of the Sun; for the Sun's Splendor not only by far exceeded the Silver Splendor of the Ring, but likewiſe the lucid ſmall Part of the Sun did not terminate in the ſame Periphery as the Ring; and the Ring appear'd more denſe on the obverſe Side of the Moon, than on the contrary Side, yet notwithſtanding it terminated in the ſame Periphery. And this Ring was obſerved by ſeveral others, as may be ſeen in the *Hiſtory of the Academy Royal of Sciences*, for the Year 1706.

2. Mr. *De Tſchirnhauſe*, at *Dreſden*, with a Teleſcope of 16 Foot long, a little before the Beginning of the aforeſaid Eclipſe, did obſerve a Trembling in that Limb of the Sun that the Moon firſt obſcur'd; as he did likewiſe in the laſt Digit, at the Inſtant of the Obſcuration. Moreover, *Kepler*, in his Book *De Nova Stella Serpentarii*, ſays, the ſame Thing was obſerved in the Year 1605, at *Antwerp* and *Naples*, in *October*, when the Sun was totally hid. And *Scheiner*, in his *Roſa Urſina*, ſays, That in an Eclipſe of the Sun, in *December* 1628, there was obſerv'd a Trembling about the Limb of the Moon: And *Hevelius*, in his *Cometography*, ſays, in ſome Eclipſes the ſame Phænomena preſented it ſelf to him.

3. Mr. *Caſſini*, in the *Memoirs de l'Acad. Royal des Sciences, An.* 1706. p. 327. ſays, he has often obſerved in the Occultations of *Saturn*, *Jupiter*, and the Fix'd Stars by the Moon, that when they come near either the enlighten'd or darken'd Limb of her, their Figures, from being Circular, appear Oval, juſt as the Sun and Moon, riſing or ſetting in a vaporous Horizon, appear not Circular, but Elliptical.

Atom, is ſuch a very ſmall Particle of Matter, that it cannot phyſically be cut or divided into leſſer Parts. *Epicurus* and his Followers firſt called the component Principals of all Bodies, which they ſuppoſed to be infinitely ſmall and hard, by this Name of Atoms.

Attick Order, is a little Order, conſiſting of Pilaſters, with a Cornice architrav'd for an Entablement.

Attraction, is the Drawing of one Thing to another. Whether among the Operations of natural Bodies upon one another, there is any ſuch Thing as Attraction, it is hard to determine; and perhaps moſt of thoſe Effects, that the Ancients not knowing ſo well the Cauſes of, may be ſolved by Pulſion. Sir *Iſaac Newton*, in his *Principia*, applies every where this Word to Centripetal Forces; and ſays, *Sect.* 11. *Lib.* 1. That Centripetal Forces are perhaps rather Impulſes, if we ſpeak phyſically: But he uſes the Word, as being familiar, and eaſier to be underſtood by Mathematicians. He demonſtrates, *Prop.* 58. *Cor.* 1.

1. That if two Bodies mutually attract each other, by Forces proportional to their Diſtances, they will deſcribe both about the common Centre of Gravity, and alſo about one another *Concentrical Ellipſes*; and *Cor.* 2. *Prop.* the ſame.

2. That if two Bodies attract one another with Forces proportional to the Squares of their Diſtances, they will deſcribe both about the common Centre of Gravity, and alſo about one another Conick Sections, having their Foci in the Centre, about which the Figures are deſcribed. And in *Prop.* 73, 74. *Lib.* 1.

3. He demonſtrates, that any Particle of Matter within the Superficies of any Sphere or Globe, is attracted by a Force proportional to the Diſtance of a Particle from the Centre of the Sphere, but without the Surface of the Sphere, by a Force proportional to the Square of its Diſtance from the Centre.

4. And in his Opticks he ſhews, That of thoſe Bodies that are of the ſame Nature, Kind, and Virtue, by how much leſs any Body is than another, the greater is its attracting Force, in proportion to its Magnitude; as the Magnetical Attraction is ſtronger in a ſmall Load-ſtone, in proportion to its Weight, than in a larger one: And ſo, ſince the Rays of Light are the ſmalleſt Bodies that we know of, they muſt needs have the greateſt and ſtrongeſt attractive Force. Now, the Attraction of a Ray of Light, with regard to its Quantity of Matter, is to the Gravity that any projected Body has, in proportion to the Quantity of Matter in that Body; in the Ratio, compounded of the Velocity of a Ray of Light, to the Velocity of that projected Body; and of the Flexure or Curvature of the Line, which the Ray deſcribes in the Place of its Refraction, to the Curvature or Flexure of the Line that the projected Body deſcribes. And from hence he calculates, that the Attraction of the Rays of Light is above 1,000,000,000,000,000 Millions of Millions of Times greater than the Force of Gravity on the Earth's Surface, according to the Quantity of Matter in each, and ſuppoſing Light to come from the Sun in about ſeven or eight Minutes: And in the very Point of Contact of the Rays, their attracting Force may be much greater.

Attractive, the ſame with *Attracting*.

Attrition, in Phyſicks, is the rubbing of one thing againſt another; as when Ember and other Electrick Bodies are rubbed, to make them attract or emit their Electrick Force.

Avant Foss, or *Ditch of the Counterscarp*, is a Moat, or Ditch, full of Water, running round the Counterscarp, on the Out-side, next to the Country, at the Foot of the Glacis. It is not proper to have such a Water-Ditch, where it can be drained dry; because it is a Trench ready made for the Besiegers to defend themselves against the Sallies of the Besieged. Besides, it hinders putting Succours into the Place, or at least makes it difficult so to do.

Auge, the same as *Apogæum*.

Auriga, a Constellation, consisting of 23 Stars in the Northern Hemisphere.

Austral, the same as *Southern*. As,

Austral Signs, are the six last Signs of the Zodiack, being called thus, because they are on the South Side of the Equinoctial.

Automata, are Mechanical or Mathematical Instruments, that, going by Springs, Weights, &c. seem to move themselves, as a Watch, Clock, &c.

Aux, the same with *Apogæum*.

Ax, or Axe, the same with *Axis*. Which see.

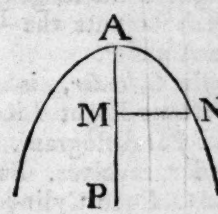
Axiom, is such a common, plain, self-evident, and receiv'd Notion, that it cannot be made more plain and evident by Demonstration, because it is itself better known than any thing that can be brought to prove it; as, *That nothing can act where it is not*; *That a Thing cannot be, and not be, at the same time*; *that the Whole is greater than a Part thereof*; *that no Bodies can naturally go into nothing*.

Axis. This properly signifies that straight Line in a plain Figure at rest, about which the Figure revolves, in order to produce or generate a Solid.

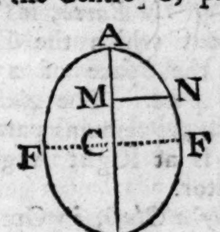
Axis *of a Balance*, is that Line about which it moves, or rather turns about.

Axis *of a Cone*, is the straight Line, or Side, about which the Right-angled Triangle, forming the Cone, moves; and so only a Right Cone can properly have an Axis, because an Oblique Cone cannot be generated by the Motion of a plain Figure about a straight Line at rest. But because it is plain from the Definition, that the Axis of a Right Cone is a straight Line, drawn from the Centre of its Base to the Vertex, therefore the Writers of Conick Sections call likewise that Line, drawn from the Centre of the Base of an Oblique Cone to the Vertex, the *Axis of the Cone*.

Axis *of a Conick Section*, is a straight Line dividing it into two equal Parts, and cutting all its Ordinates at Right Angles: As, if A P be drawn so as to cut the Ordinate M N at Right Angles, and dividing the Section into two equal Parts, then is the Line A P the Axis of the Section.

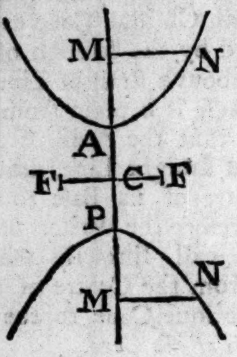


Axis (Conjugate, or Second) *of an Ellipsis*, is the Line E F drawn through the Centre C, parallel to



the Ordinate M N to the Ax A P, being terminated by the Curve, and is the shorter of the two Axes. And the

AXIS (CONJUGATE or SECOND) *of an Hyperbola*, is the Right Line F F drawn thro' the Centre C, parallel to the Ordinates M N, M N, to the Axis A P, which cuts the



Curve in the Points A and P. This Axis (tho' more than infinite) is of a determinate Length, which may be found by this Proportion, as $\overline{AM} \times \overline{PM} : AP^2 :: MN^2 : FF^2$.

AXIS (TRANSVERSE, or FIRST, or PRINCIPAL) *of an Ellipsis, or Hyperbola*, is the Axis A P, which in the Ellipsis is the longest, and in the Hyperbola cuts the Curve in the Points A and P.

AXIS *of a Cylinder*, is properly that Quiescent Right Line, about which the Parallelogram, forming the Cylinder, revolves. But in both Right and Oblique Cylinders, that Right Line, joining the Centres of the opposite Bases, is called the Axis of the Cylinder.

AXIS *of the Earth*, is a Right Line, about which the Earth revolves in the Space of 23 ho. 56 min. and 4 sec. The *Axis of the Earth* always remains parallel to it self, and is at Right Angles with the Equator.

AXIS *of a Glass*, in Opticks, is a Right Line, joining the middle Points of the two opposite Surfaces of the Glass.

AXIS *of Incidence*, in Dioptricks, is a Right Line perpendicular in the Point of Incidence to the refracting Superficies, drawn in the same Medium that the Ray of Incidence comes from.

AXIS *in Opticks*, is that Ray, among all those that are sent to the Eye, which falls perpendicularly upon it, and which by consequence passes through the Centre of the Eye.

AXIS *of Oscillation*, is a Right Line parallel to the Horizon, passing thro' the Centre, about which a Pendulum vibrates.

The *Axis of the Parabola* is of an indeterminate Length, that is, it is infinite. The *Axis of the Ellipsis* is determinate : And the *Axis of the Hyperbola* is of a determinate Length, (tho' it is more than infinite.) In the *Ellipsis* or *Hyperbola* there are two Axes, and no more ; and in the Parabola one. And the

AXIS *in Peritrochio*, is a Machine for the Raising of Weights, consisting of a cylindrical Beam, which is the Axis lying horizontally, and supported at each end by a Piece of Timber, and somewhere about it has a kind of Tympanum, or Wheel, which is called the *Peritrochium*, in whose Circumference are Holes made to put in Staves, (like those of a Windlass or Capstan,) in order to turn the Axis round more easily, and thereby to raise the Weight requir'd by means of a Rope, which winds round the Axis.

In this Instrument, and all such like, as all Crane-Wheels, Mill-Wheels, &c. if the Power that is to lift up any Weight, be to the Weight as the Cicumference of the Axis, about which the Rope is winded, is to the Circumference of the Tympanum or Peritrochium, then the Power will sustain the Weight ; and if it be a little augmented it, will raise it.

AXIS *of any Planet*, is that Line drawn

drawn through the Centre, about which the Planet revolves.

All the Planets, and the Sun itself, except *Mercury* and *Saturn*, are observed to move about their Axes.

Axis *of Refraction*, is a right Line drawn from the Refracting Medium, from the Point of Refraction, perpendicular to the Refracting Superficies.

Axis *of a Sphere*, is a streight Line drawn thro' the Centre thereof from one side to another, being terminated by the Surface, and is the same as the Diameter of a Sphere.

Axis *of the World*, is an imaginary right Line, conceived to pass thro' the Centre of the Earth, from one Pole to the other, about which the Sphere of the World, in the *Ptolemaick* System, revolves in its Diurnal Motion.

Azimuth *of the Sun, or any Star*, is an Arch of the Horizon, intercepted between the Meridian and the Vertical Circle the Sun is in; or it is the Complement to a Quadrant of the Ortive and Occasive Amplitude. As R : T. *Lat*. : : T. ☉'s *Altit*. : Co-S. of the Azimuth from the South at the Time of the Equinox.

Azimuth Compass, is a Compass that takes its Name from its Use, which is principally to find the Sun's Magnetical Azimuth at Sea, and does not much differ from the common Sea-Compasses.

It consists of a round Box, having a Fly and Needle in it; and upon that Box is a broad Brass Circle, having one half of the Limb thereof divided into 90 Degrees, and diagonally divided into Minutes. Upon this Limb there moves an Index; and upon this Index there is erected a Sight, which for Conveniency is to fall down with an Hinge; and from the Top of this Sight, down to the Middle of the Index, is fasten'd a Thread, to shew the Shadow of the Sun upon a Line that is on the Middle of the Index. This Compass being thus fitted, is hung in strong Brass Rings, and the Rings are hung in a Wainscot Square Box.

Azimuth Magnetical, is an Arch of the Horizon contained between the Azimuth Circle the Sun is in and the Magnetical Meridian; or it is the apparent Distance of the Sun from the North or South Point of the Compass; and is found by observing the Sun by the Azimuth Compass, either in the Forenoon or Afternoon, when he is about five or ten Degrees above the Horizon.

B.

Babylonish Hour. A *Babylonish* Hour is the 24th Part of the Time from the Sun-rising of one Day, to Sun-setting of the next, being reckoned from the Sun-rising.

Back-Staff, the same with the *Sea-Quadrant, Davis's*, or the *English Quadrant*, as the *French* call it. It was invented by Captain *Davis*, a *Welchman*; and is of good Use for taking the Sun's Altitude at Sea, and consists of two concentrick Arches of Box-Wood; the Arch of the greater Circle being divided into 30 Degrees, and every Degree into five Minutes, by means of Diagonals; and the Arch of the lesser into 60 Degrees. There are likewise three Vanes belonging to it; that upon the Arch of 30 Degrees being called the Sight-Vane; that upon the Arch of 60, the Shade-Vane; and the other Vane, being in the Centre of the Arches, the Horizon-Vane.

Bacule, *in Fortification*, is a kind of Port-Cullis, or Gate, made like

like a Pitfall, with a Counterpoiſe, and ſupported by two great Stakes. It is uſually made before the *Corps-de-Gard*, advanced near the Gates.

BACULOMETRY, according to ſome, is the Art of meaſuring acceſſible or inacceſſible Lines, by the help of one or more Staves.

BAKER'S CENTRAL RULE, *for the Conſtruction of Equations*, is a Method of conſtructing all Equations, not exceeding four Dimenſions, without any previous Reduction of them, or firſt taking away their ſecond Term by means of a given Parabola and a Circle. See his *Clavis Geometrica Catholica*.

BALDACHIN, *in Architecture*, is a Building in form of a Canopy, or Crown, ſupported by Pillars, often ſerving for the Covering of an Altar. Some alſo call the Shell over a Door by this Name, and pronounce it *Baldaquinin*.

BALL and SOCKET, is an Inſtrument made of Braſs, with a perpetual Screw, to hold a Teleſcope, Quadrant, or ſurveying Inſtrument on a Staff, for Surveying, Aſtronomical or other Uſes.

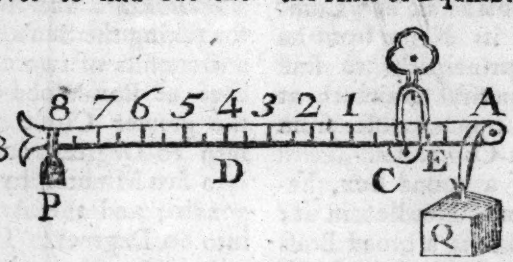
BALLANCE, or *Scales*, is one of the ſix ſimple Powers in Mechanicks, and ſerves to find out the Equality or Difference of Weights in heavy Bodies.

The Action of a Weight to move a Ballance is by ſo much greater, as the Point preſſed by the Weight is more diſtant from the Centre of the Ballance; and that Action follows the Proportion of the Diſtance of the ſaid Point from the Centre.

A Ballance is ſaid to be in Equilibrio, when the Action of the Weights upon each Brachium, to move the Ballance, are equal, ſo that they mutually deſtroy one another.

Unequal Weights can equiponderate; for if the Diſtances from the Centre be reciprocally as the Weights, the Ballances will be in Equilibrio; as one Ounce, at nine Inches diſtance from the Centre, will equiponderate with three Ounces at three Inches diſtance from the Centre: And upon this Principle is made the

Roman Ballance, or *Steel-Yard*, which weighs every Thing with one Weight, and is a Leaver of unequal Arms, one of which C A is extended in length from the Axis of Motion C, (and which ought to be the Axis of Equilibrium) ſuppoſe one



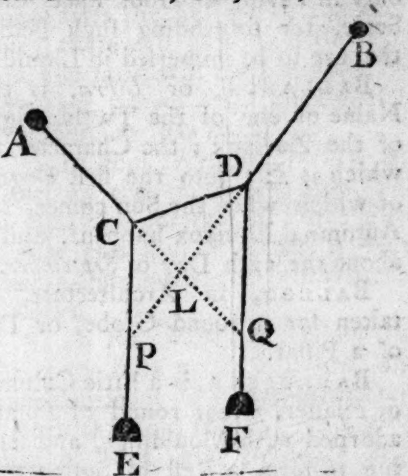
Inch or leſs; the other Arm C B being of a greater length, divided into Parts, each equal to A C, and numbered by the Figures 1, 2, 3, 4, 5, &c. then, if a Body whoſe Weight Q we want to diſcover, be hang'd on at A, and the given Weight P, moveable on the contrary Arm, be moved towards, or put farther from the Centre C, the Number whereat it hangs, will ſhew how much it weighs. For example, if the Weight P, at the Diſtance 8, equiponderates the Weight Q at A, it muſt follow, by reaſon the Weights are reciprocally to their Diſtances from C, that the weight Q, is eight times the weight

weight P; that is, if P, be one Pound; Q, will be eight Pounds.

Altho' this be the usual Description of the *Roman* Steel-Yard, yet it must be false, when the Arms, being of one continued Thickness, are divided into the Parts 1, 2, 3, 4, *&c.* each equal to AC, unless the Arms have no weight, and so much the more false, the heavier the Matter of which they consist, is. For, suppose the weight of the Arm CA, to be *w*, and that of CB to be W, and bissect CB in D, and CA in E, then will D, E, be the Centers of Gravity of the Arms CB, CA. Consequently the Weights P, W, and Q, *w*, will be in Equilibrio about the Center C; it must be $\frac{1}{2}BC\times W + P\times PC = \frac{1}{2}AC\times w + Q\times CA$. Wherefore PC will be $= \frac{\overline{2Q+w}\times AC - W\times BC}{2P}$, that is, since 2P is given; PC will be always as $\overline{2Q+w}\times AC - BC\times W$. Or, supposing AC to be $=1$, P to be 1, and *w* to be 1; then will W be $=$ CB, and so P will be always as $\overline{2Q+1} - \overline{CB}^2$. And since this last Expression is not as Q; and therefore P not as Q; the Divisions of the Arm CB will not be as the Weights Q. Much after the same way, it will appear that the Divisions will be more unequal, if the two Arms consisted of a Cone or Frustum of one, or prismatical Pyramid or Frustum of one. So that the only true Way of making a Ballance of this sort, is to do it mechanically, *viz.* by first hanging at Q various different Weights, and then moving the given Weight P backwards or forwards along the Arm CB till there be an Equilibrium: and marking down that Number expressing the Weight Q, upon the Place where P hangs: And if the several Weights Q be Pounds; and each of the Distances thus mark'd upon the Arm BC, be divided into four equal Parts, these, without any great Error may be taken for Divisions, for Quarters, half Pounds, and three Quarters; provided the Arms be throughout of the same Thickness, and uniform Matter. But however convenient the Use of this Instrument may be, by reason of its not requiring several Weights; yet the Use of it is not to be too much indulged amongst Trades-People; who, thereby may deal out false Weight, that cannot be readily discovered by those who buy their Goods.

Sir *Isaac Newton*, in his *Universal Arithmetic*, *Prop.* 49. hints at a Ballance or Steel-Yard, consisting of Strings only, whereby the Weight of any Body E, may be known by only one Weight F. What he says is contained in the following Problem.

A String ACDB, *being divided into given Parts* AC, CD, DB, *and its*



Ends being fastened to two Pins A, B, *given in Position, and if to the Points of Division* C, D, *be hung the two Weights* E *and* F: *To find the weight* E, *from the given weight* F, *and the Situation of the Point* C, D. Continue out the Lines AC, DB, until they meet the Lines DF, CE, in the Points Q, P; then will the weight E be to the weight F, as DQ to CP.

Ballance *of a Clock or Watch*, is that Part of it which by its Motion regulates and determines the Beats: The Circular Part of it is called the Rim, and its Spindle, the Verge. There belongs also two Pallets, or Nuts, that play in the Fangs of the Crown-Wheel. In Pocket-Watches that strong Stud in which the lower Pevet of the Verge lies, and in the middle of which one Pevet of the Crown-Wheel runs, is called the *Potans*, or rather the *Potence*; the wrought Piece, which covers the Ballance, and in which the upper Pevet of the Ballance plays, is the *Cock*; and the small Spring in Watches is called the *Regulator*.

Ballance (Hydrostatical) is a very exact Pair of Scales, for making Hydrostatical Experiments, relating to the Gravity of Fluids; and they differ from common Scales only in having an Hook under each Scale, for suspending such Bodies that are to be immersed in Liquids.

Ballance, or *Libra*, is the Name of one of the Twelve Signs of the Zodiack; the Character of which is ♎; into the first Degree of which when the Sun comes, the Autumnal Equinox happens, and is about the 12th Day of *September*.

Ballon, in Architecture, is taken for a round Globe, or Top of a Pillar.

Ballustter, is a little Column, or Pilaster, either round or square, adorned with Mouldings, and serving to form a Rest or Support to the Arm, and, in some measure, to answer the Ends of a Balcony.

Ballustrade, in Architecture, is the Continuity of one or more Rows of Ballusters, made of Marble, Iron, Wood, or Stone, serving either for an Elbow-Rest, as in Windows, Balconies, and Terrasses, or as a Fence, to keep off Things from without. And thus we see them around some Altars, Fonts, *&c.*

Band, in Architecture, is any flat Member that is broad, and not very deep; and the Word *Face* is sometimes made to signify the same thing.

Banquette, in Fortification, is a little Foot-pace or Elevation of Earth, in figure of a Step, at the bottom of a Parapet, or that which the Soldiers get upon to discover the Counterscarp, or to fire upon the Enemy in the Moat, or in the Covert-Way. These Banquettes are generally a Foot and an half high, and almost three Feet broad.

Barometer, or *Baroscope*, is an Instrument for estimating the small Variations of the Weight or Pressure of the incumbent Air. From whence we can give a tolerable Judgment of the Weather; and consists of a Tube of Glass of above thirty Inches long, hermetically sealed at one End, and being filled with Quicksilver, according to the *Torricellian* Experiment is inverted, so as to have the open End of it mmersed in stagnant Quicksilver, contain'd in a larger Glass under it; out of which open End, after such Immersion, the Quicksilver in the Tube being suffer'd to run as much as it will into the stagnant Quicksilver, there remains a Cylinder of Quicksilver suspended in the Tube, that will be always between 28 and 30 Inches in height, above the Surface of the stagnant Mercury, according as the Pressure of the Air is more or less; and the upper Part of the Tube will be left void of common Air. This is the common Barometer; but there are others, as the

Barometer, (Diagonal,) where the Mercury, instead of rising three Inches, as in the common one, rises obliquely near thirty Inches, which is made by bending a *Torricelian* Tube of more than 58 Inches long, at the 218h i nch above the Sur-

Surface of the ſtagnant Mercury; ſo that the encloſed End thereof, when the lower Part of the Tube ſtands upright in the ſtagnant Mercury, is more than thirty Inches above the Surface of the ſtagnant Mercury. This Barometer, of all others, is the beſt,

BAROMETER (MARINE,) is an Inſtrument ſerving for the ſame Uſes at Sea, as the common Barometer at Land, and conſiſts of an Air-Thermometer, and a Spirit-Thermometer; for the Mercurial Barometer, eſpecially the common ones, cannot be uſed at Sea, becauſe it always requires a perpendicular Poſture, and the Quickſilver vibrates therein with a great Violence, upon any Agitation. See the Deſcription and Uſes of this Inſtrument, by Dr. *Halley*, in the *Philoſophical Tranſactions*, N° 269. who carried one of them along with him in his laſt Southern Voyage; and he ſaid, that it never failed to give him early Notice of a Storm, and of all the bad Weather they had.

BAROMETER (PORTABLE,) is one that can be conveniently and ſafely carried about from Place to Place, without the danger of ſpilling the Mercury out of the Ciſtern, or Veſſel, or letting the Air get in at the bottom of the Tube; or the Mercury, included in the Tube, breaking the Top of it off.

BAROMETER (WHEEL,) is a common Barometer with an Index, that ſhews the Variation of the Altitude of the Mercurial Cylinder, which at moſt does not exceed three Inches; tho' by this Index it may be made as diſtinguiſhable as if it were three Foot, or three Yards. The Manner of making one of theſe Barometers is ſhewn us by Dr. *Hook*, in the *Philoſophical Tranſactions*, N° 185.

1. The higher the Barometer is above the Surface of the Earth, the lower will the Mercury in the Tube ſink. This was obſerved firſt by Mr. *Paſchal*, in his Treatiſe *De Equilibrio Liquorum*.

2. The Motion of the Mercury does not exceed three Inches in its Riſing or Falling in the Barometer of the common Form.

3. The Riſing of the Mercury preſages, in general, fair Weather, and its Falling, foul; as Rain, Snow, high Winds, and Storms.

4. In very hot Weather, the Falling of the Mercury foreſhews Thunder.

5. In Winter, the Riſing preſages Froſt; and in froſty Weather, if the Mercury falls three or four Diviſions, there will certainly follow a Thaw: but in a continued Froſt, if the Mercury riſes, it will certainly ſnow.

6. When foul Weather happens ſoon after the Falling of the Mercury, there will be but a little of it; and the ſame will happen when the Weather proves fair, ſhortly after the Mercury has riſen.

7. In foul Weather, when the Mercury riſes much and high, and ſo continues for two or three Days before the foul Weather is over, then a Continuance of fair Weather follows.

8. In fair Weather, when the Mercury falls much and low, and thus continues for two or three Days before the Rain comes, then a great deal of Wet, and probably high Winds follow.

9. The unſettled Motion of the Mercury denotes uncertain and changeable Weather.

10. More Northerly Places have a greater Alteration of the Riſe or Fall of the Mercury than the more Southerly.

11. Within the Tropics, and near them, there is little or no Variation

of the Height of the Mercury in all Weathers.

12. The Words that are graved near the Divisions of the Instrument, are not so strictly to be minded, although, for the most part, it will agree with them, as the Rising and Falling of the Mercury; for if it stands at much Rain, and then rises up to Changeable, it presages fair Weather, altho' not to continue so long as it would have done, if the Mercury were higher: and so on the contrary.

13. It is confirmed from Barometrical Tables, and the Remarks of several curious Observers of this Instrument, that the greatest Risings and Fallings of the Mercury in Places at a good Distance from each other, happen commonly on the same Day, and the Barometers have been found to agree in their Motion to an Hour, so far asunder as *Townley* in *Lancashire*, and *Greenwich* near *London*; so that it might be expected that the Weather would be the same at those distant Places. But it is often otherwise: And the Barometrical Alterations of the Air, extend farther than their Effects, as to the Production of Rains.

14. The mean Height of the Barometer may be apply'd to find the respective Heights of Places, as well as their absolute Height above the Surface of the Sea. See Dr. *Scheuchzer's Tables*, in the *Philosophical Transactions*. N° 405, 406, where he supposes the mean Height at the Surface of the Sea to be 29.993 Inches, and allowing about 90 Feet for each 10th of an Inch in the Height of the Mercury in smaller Altitudes, or in greater, according to the Tables of Dr. *Scheuchzer* and Dr. *Nettleton*, N° 388. of the said *Transactions*, you will have the Height of each Place pretty near.

15. It is not necessary, for the wooden Vessel which holds the Mercury of the Barometer, to be open, as Mr. *Wolfe* has shewn in the *Acta Eruditorum* of *Leipsick*: For he says he found by Experience, when it is every way so well enclosed as to admit scarcely the least Quantity of external Air to fall upon the Surface of the Mercury, that, notwithstanding, the Changes in the Height of the Mercury, were not in the least altered or disturbed.

16. In *England*, and these Parts of the World, it has been long observed, that the Rising of the Mercury foretels fair Weather after foul, and an Easterly or Northerly Wind; and that on the contrary, the Falling thereof, signifies Southerly or Westerly Winds, with Rain, and stormy Winds, or both; and in a Storm, when the Mercury begins to rise, it is a certain sign that it begins to abate: and this has most commonly been found to be true in high Latitudes both to the North and South of the Equator. Moreover, in Foggy Weather the Mercury is usually high.

17. The most rational Account of all these Alterations of the Rising and Falling of the Mercury, is that of Dr. *Halley* in the *Philosophical Transactions*, N° 187. which, he says, are caused by the variable Winds, blowing in the temperate Zones, and the uncertain Exhalations and Precipitations of Vapours lodging in the Air, whereby it comes to be at one time, much more crouded than at another, and consequently heavier: But these latter depend upon the former. — He says, *the Lowness of the Mercury in rainy Weather*, is caused by the Air's becoming lighter, so as not to be able to support the Vapours swimming in the Air.-- *That the Mercury's being lower at one Time than another*, is caused by two contrary Winds blowing from the Place where the Barometer stands. —That *the greater*

er Height of the Mercury in Fair Weather, is caused by two contrary Winds blowing towards the Place whereat the Barometer stands, whereby the Air of other Places is brought there and accumulated, and the Mercury pressed up higher in its Tube.— That *the extraordinary Sinking of the Mercury in great Storms*, is caused by the rapid Motion of the Air in these Storms; because the Tract or Region of the Earth's Surface, wherein these Winds rage, not extending all round the Globe; that stagnant Air which is left behind, as also on the Sides, cannot come in so fast to supply the Evacuation, made by so swift a Current, so that the Air must necessarily be attenuated, when and where the said Winds continue to blow, more or less, according to their Violence.— That *the Mercury stands highest*, cæteris paribus, *upon Easterly or North-Easterly Winds*, happens, because that in the Atlantic-Ocean, on this side the 35th Degree of North Latitude, the Westerly and South-Westerly Winds, are always Trade-Winds; so that, whenever the Wind here comes up at East, or North-East, it is check'd by a contrary Gale, as soon as it reaches the Ocean, and so the Air must be accumulated over this Island, and cause the Mercury to stand high. But tho' this be true for our Country, it is not a general Rule for others, where the Winds are under different Circumstances.--That *the Mercury generally stands high in Frosty Weather*; is, because it seldom freezes, but when the Wind is Easterly or North, and so the Air brought here from the Northern or North-Easterly Countries, which are subject to almost continual Frost in Winter, is very much condensed, and accumulated by the Opposition of the Westerly Wind blowing in the Ocean.—That *the fast Rising of the Mercury after very great Storms, when it has been very low*, seems to be occasioned by the sudden Accession of new Air to supply the great Evacuation, which continued Storms make thereof, in those Places, where they happen; and, by the Recoil of the Air, after the Force ceases that impell'd it.—That *the Variations of the Barometer in the more Northerly Places*, seem to arise from the greater Storms, happening in those Places, than in those more Southerly, whereby the Mercury should sink lower in that extreme; and then the Northerly Winds bringing the condensed and ponderous Air from the Neighbourhood of the Pole, and that again being check'd by a Southerly Wind, at a small distance, and so heaped, must necessarily make the Mercury in such a Case stand higher on the other Extreme.—That *near the Equator, as at* Barbadoes, *and* St. Helena *there is very little or no Variation of the Height of the Mercury*, is, because of the steady Winds constantly blowing in those Parts, nearly upon the same Point, *viz.* E. N. E. at *Barbadoes*, and E. S. E. at *St. Helena*, so that there being no contrary Current of the Air to exhaust or accumulate it; the Atmosphere continues much in the same State: Altho', indeed sometimes upon *Hurricanes*, it has been observed to have been very low.

This is the Substance of what the Doctor says, about the Causes of the Rising and Falling of the Mercury of the Barometer; which, altho' not satisfactory, perhaps, in several things, yet we may very well acquiesce therein, till somebody gives us better.

There are several Writings about Barometers, as *Descartes*'s, Mr. *Boyle*'s, Mr. *Huygens*'s, Mr. *Paschal*'s, Mr. *Dalence*'s *Traittez des Barometres, Thermometres, & Notiometres*, Mr. *De la Hire*'s, in the *French Memoirs*,

Dr.

Dr. *Hook*'s in our *Transactions*, N° 185, Mr. *Saul*'s, Mr. *Amonton*'s in *Memoirs of the French Academy, for the Year* 1705, and many others.

Baroscope, the ſame with *Barometer*. Which ſee.

Barrel, an *Engliſh* Veſſel for Beer, containing 36 Gallons.

Barrel, in Clock-Work, is the Cylinder about which the Spring is wrapped.

Barriers, in Fortification, are great Stakes, about four or five Foot high, placed at the Diſtance of eight or ten Foot from one another, with their Tranſoms, or Overthwart-Rafters, to ſtop either Horſe or Foot, that would enter or ruſh in with Violence. Theſe Barriers are commonly ſet up in the void Space, between the Citadel and the Town, in Half-Moons.

Bars, in Muſic, are the Spaces quite through any Compoſition, ſeparated by upright Lines drawn acroſs the five horizontal Lines, each of which, either contains the ſame Number of Notes, of the ſame kind, as two Minims, two Crochets; three Minims, three Crochets, *&c.* or elſe contains ſo many of various Kinds, that are in Length of Time, equivalent to the ſame Number of one Kind.

Base, in Architecture, is the Foot of a Pillar, that ſuſtains it, or that Part that is under the Body, or lies upon the Pedeſtal, or Zocle, when there is any; and therefore is not uſed for the loweſt Part of a Column, but for all the ſeveral Ornaments or Mouldings that reach from the *Apophyges*, or Riſing of the Shafts of Pillars to the *Plinth*.

Base *of any ſolid Figure*, is its lowermoſt plain Side, or that on which it ſtands; and if the Solid has two oppoſite, parallel, plain Sides, and one of them is the Baſe, then the other is alſo called its Baſe.

Base, in Fortification, is the exterior Side of the Polygon, *viz.* the imaginary Line, which is drawn from the flank'd Angle of a Baſtion to the Angle oppoſite to it.

Base Line, in Perſpective, is the common Section of the Picture, and the Geometrical Plane.

Base, *the leaſt Sort of Ordnance*; the Diameter of whoſe Bore is 1 $\frac{1}{4}$ Inch, Weight 200 Pound, Length four Foot, Load five Pound, Shot 1 $\frac{1}{4}$ Pound Weight, and 1 $\frac{1}{2}$ Inch Diameter.

Base Ring *of a Cannon*, is the great Ring next behind the Touch-Hole.

Base *of a Triangle*. Any one Side of a Triangle may be call'd the *Baſe*; but uſually and more properly, that Side that lies the loweſt, or is parallel to the Horizon, is taken for the Baſe. And the ſame is to be underſtood of the Baſe of any other plain Figure.

Basilic, a large Piece of Ordnance, being a forty-eight Pounder, thoſe of the *French* being ten Feet long, and thoſe of the *Dutch* fifteen Feet.

Basilic. This, among the Antients, was a large Hall, with Portico's, Iſles, Tribunes, and Tribunal; where the Kings themſelves adminiſter'd Juſtice. But the Name is ſomewhat differently applied now-a-days, being given to Churches and Temples, as alſo to certain ſpacious Halls in Princes Courts, where the People hold their Aſſemblies, and the Merchants meet, and converſe together; as that, for Inſtance, of the Palace at *Paris*.

Basilicus, *Cor Leonis*, a fixed Star of the firſt Magnitude in the Conſtellation *Leo*. Its Longitude is 145 deg. 21 min. Latitude 26 min. and Right Aſcenſion 147 deg. 47 min.

Ba s, in Muſic, is the loweſt and the fundamental Part thereof, without which any Piece of Muſic is imperfect.

Bassoon, a Wind-Inſtrument being a Baſs to the Haut-Boy.

Bass-

Bass-Viol, a Bass to the Violin.

Bastion, in Fortification, is now what was antiently called a Bulwark; and consists of two Faces, and as many Flanks, formerly called a *Gorge*. It is usually made, at the Angles of Forts, of a large Heap of Earth; sometimes lined with Stone, or Brick, but usually faced with Sods, or Turfs. The Lines terminating it are two Faces, two Flanks and two Demi-Gorges. The Union of the two Faces makes the utmost Angle, called the *Angle of the Bastion*; and the Union of the two Faces to the two Flanks, makes the Side-Angles, called the *Shoulders*, or *Epaules*; and the Union of the two other Ends of the Flanks, to the two Curtains, forms the Angles of the Flanks.

Bastion (Compos'd,) is when the two Sides of the Interior Polygon are very unequal, which makes the Gorges also unequal.

Bastion (Cut,) is that which makes a Re-entering Angle at the Point, and is sometimes called

Bastion *with a Tenaille*, whose Point is cut off, and makes an Angle inwards, and two Points outwards. This is done when Water, *&c.* hinders carrying the Bastion to its full Extent, or when it would be too sharp.

Bastion (Deformed,) is that which wants one of its Demi-Gorges, because one Side of the Interior Polygon is so very short.

Bastion (Demi,) has but one Face and Flank, and is usually before a Horn-work, or Crown-work. This is also called an *Epaulment*.

Bastion (Double) is that which, on the Plane of the great Bastion, hath another Bastion built higher, leaving 12 or 18 Feet between the Parapet of the lower, and Foot of the higher.

Bastion (Flat,) is that which is built on a Right Line. If the Distance between the Angles of the Interior Polygon be double the usual Length, then a Bastion is made in the Middle, before the Curtain. But it generally has this Disadvantage, That unless there be an extraordinary Breadth allowed to the Moat, the turning Angle of the Counterscarp runs back too far into the Ditch, and hinders the Sight and Defence of the two opposite Flanks.

Bastion (Regular,) is that which has its due Proportion of Faces, Flanks, and Gorges.

Bastions (Solid,) are those that have their Earth equal to the Height of the Rampart, without any void Space towards the Centre.

Bastions (Void or Hollow,) are those that have a Rampart and Parapet ranging only round about their Flanks and Faces, so that a void Space is left towards the Centre, and the Ground is there so low, that if the Rampart be taken, no Retrenchment can be made in the Centre, but what will lie under the Fire of the Besieged.

Baston, a *French* Word in Architecture, the same with *Torus*.

Batten, is the Workmen's Name for a Scantling of Wooden Stuff, from two to four Inches broad, and about an Inch thick, and of a considerable Length.

Battery, in Fortification, is a Place raised on purpose, where Cannon are planted, from thence to play upon the Enemy; the Platform on which they are fixed being made of Planks that support the Wheels of the Carriages, so as to hinder the Weight of the Cannon from sinking them into the Ground; and incline a little to the Parapet so as to check the Recoiling of the Pieces.

In all Batteries, the open Spaces, left to put the Muzzles of the great Guns out, are call'd *Embrazures*, and the Distances between the Embrazures,

brazures, *Merlons*; the Guns are generally about 12 Foot diſtant one from another, that the Parapet may be ſtrong, and the Gunners have room to work.

Batteries (Cross,) are two Batteries, which play athwart one another, upon the ſame Thing, forming there an Angle, and beating with more Violence and Deſtruction, becauſe, what one Battery ſhakes, the other beats down.

Battery (de Enfilade,) is one that ſcours or ſweeps the whole Length of a ſtraight Line.

Battery (en Escharp,) is that which plays obliquely.

Battery (Joint, or par Camerade,) is when ſeveral Guns play at the ſame time upon any Place.

Battery (de Reverse,) or *Murdering Battery*, is one that bears upon the Back of any Place.

Battery (Sunk or Buried,) is when its Platform is ſunk, or let down into the Ground, ſo that there muſt be Trenches cut in the Earth againſt the Muzzles of the Guns, for them to fire out at, and to ſerve for Embrazures. This ſort of Battery, which the *French* call *en Terre*, and *Ruinate*, is generally uſed on the firſt making of Approaches, to beat down the Parapet of any Place.

Battlements, are the Tops of the Walls of Buildings, made in the Form of Embrazures and Merlons, in fortify'd Places.

Bay, a Term in Geography, is an Arm of the Sea, coming up into the Land, and terminated in a Nook. It is a kind of leſſer Gulph, bigger than a Creek; and is larger in the Middle within, than it is at the Entrance into it; which Entrance is called the *Mouth of the Bay*.

Beacons, are Fires maintained on the Sea Coaſt, to prevent Shipwrecks, and to give notice of Invaſions, &c.

Bead, in Architecture, is a Moulding, which in the *Corinthian* and *Roman* Orders, is cut and carved into ſhort Emboſſments, which look like Beads worn in Necklaces; and ſometimes an Aſtragal is thus carved.

A *Bead Plain* is ſometimes ſet alſo on the Edge of each Faſcia of an Architrave. Its Convexity is uſually about a Quarter of a Circle, and differs from a Boultine, only in not being ſo large. A Bead is often placed on the Lining-Board of a Door-Caſe, and on the upper Edges of Skirting-Boards.

Beam, in any Building, is a Piece of Timber lying acroſs it, and into which the Feet of the principal Rafters are framed. No Building has leſs than two of theſe Beams, *viz.* one at each Head; and into theſe Beams the Girders of the Garret-Floor are framed; and if it be a Timber Building, into them the Teazle-Tennons of the Poſts are alſo framed.

Beam Compass, is an Inſtrument conſiſting of a ſquare Wooden or Braſs-Beam, having ſliding Sockets, that carry Steel or Pencil Points; and they are uſed for deſcribing large Circles, where the common Compaſſes are uſeleſs.

Bear. There are two Conſtellations of Stars called by this Name, the *Greater* and *Leſſer Bear*, or *Urſa Major* and *Minor*; and the *Pole-Star* is in the Tail of the Leſſer, which is never diſtant from the North-Pole of the World above two Degrees.

Bearer, in Architecture, is a Poſt, or Brick-Wall, which is trimmed up between the two Ends of a Piece of Timber, to ſhorten its Bearing, or to prevent its Bearing with the whole Weight at the Ends only.

Bearing, in Navigation, ſignifies the Point of the Compaſs that one Place bears or ſtands off from another: Or if there are two Places,

A and B, propoſed, then B is ſaid to bear from A, by the Quantity of an Angle contained under an infinitely ſmall Part of a Rhumb-Line, drawn thro' both the Places at the Place A, and an infinitely ſmall Part of the Meridian of the Place A.

Beats, in a Watch or Clock, are the Strokes made by the Fangs or Pallets of the Spindle of the Ballance; or of the Pads in a royal Pendulum.

1. As the Beats of the Ballance in one Hour are to the Beats in one Turn of the Fuſy, ſo is the Number of the Turns of the Fuſy to the Continuance of a Watch's going.

2. As the Number of Turns of the Fuſy is to the Continuance of a Watch's Going in Hours, ſo are the Beats in one Hour to the Beats of the Ballance in one Turn of the Fuſy.

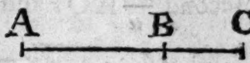
Bed *of the Carriage of a great Gun*, is that thick Plank which lies immediately under the Piece, being as it were, the Body of the Carriage.

Bed-Moulding, is a Term uſed by Workmen for thoſe Members in a Cornice which are placed below the Coronet, or Crown. And now-a-days, a Bed-Moulding uſually conſiſts of theſe four Members: 1. An Ogee. 2. A Liſt. 3. A large Boultinee. 4. Under the Coronet another Liſt.

Berme in Fortification, is a little Space of Ground, three, four, or five Foot wide, left without, between the Foot of the Rampart, and the Side of the Moat, to receive the Earth that rolls down from thence, and to prevent its falling into the Moat. Sometimes, for more Security, the Berme is palliſado'd.

Bevel, an Inſtrument uſed by Carpenters and Bricklayers for adjuſting of Angles.

Bimedial. If two Medial Lines, as A B and B C, commenſurable only in Power, containing a rational Rectangle, are compounded, the whole Line A C will be irrational,



and is called a *Firſt Bimedial Line* See *Euclid, Lib.* 10. *Prop.* 38.

Binomial Root, is a Root compos'd of two Parts or Members, and no more, connected together by the Sign *Plus* $+$. Thus $a+b$, or $2+3$ is a *Binomial Root*, conſiſting of the Sum of thoſe two Quantities. If it has three Parts, as $a+b+c$, it is called a *Trinomial Root*; if it has four, a Quadrinomial.

Any Root m of the Binomial $a+b$ may be extracted, or it may be raiſed to any given Power m by the following Series in Form of a Theorem, *viz.* $\overline{P+PQ}|^{\frac{m}{n}} = P^{\frac{m}{n}} + \frac{m}{n} AQ + \frac{m-n}{2n} BQ + \frac{m-2n}{4n} CQ + \frac{m-3}{4n} n.\, DQ +$ &c. where $P+PQ$ ſignifies the Quantity whoſe Root, or any Dimenſion, or Root of the Dimenſion, is to be found. P is the firſt Term of that Quantity; Q the next of the Terms divided by the firſt and $\frac{m}{n}$ is the numerical Index of the Dimenſions of $P+PQ$; whether that Dimenſion be Integral or Fractional, that is, repreſents a Power or Root; or whether it be affirmative or negative; as ſuppoſe, in the Binomial $\overline{a^3+bxx}|^{-\frac{2}{3}} \left(= \frac{1}{\overline{a^3+bxx}|^{\frac{2}{3}}} \right)$ $\overline{a^3+bxx}|^{-\frac{2}{3}}$, will be (in the Theorem) $\overline{P+PQ}|^{\frac{m}{n}}$; P will be $= a^3$; $Q = \frac{bbx,}{a}$ $m = -2$, $n = 3$; the Letters A, B, C, D, &c. ſtand for the Terms already found in the Quotient. A for the firſt Term $P^{\frac{m}{n}}$:

B for the second $\frac{m}{n}AQ$; and so on.

For Example $\sqrt{cc+xx} = \overline{cc+xx}|^{\frac{1}{2}} = c + \frac{xx}{2c} - \frac{x^4}{8c^3} + \frac{x^6}{16c^5} - \frac{5x^8}{128c^7} + \frac{7x^9}{256c^9}$, &c. For in this Case $P = cc$, $Q = \frac{xx}{cc}$, $m = 1$, $n = 2$, $A\ (= P^{\frac{m}{n}} = cc^{\frac{1}{2}}) = c$; $B\ (= \frac{m}{n}AQ) = \frac{xx}{2c}$; $C\ (= \frac{m-n}{2n}BQ) = - \frac{x^4}{8c^3}$, and so on.

In like manner $\sqrt[5]{c^5+c^4x-x^5}$ (that is $\overline{c^5+c^4x-x^5}|^{\frac{1}{5}}$) will be $= c + \frac{c^4x-x^5}{5c^4} - \frac{2c^8xx+4c^4x^6-2x^{10}}{25c^9}$ + &c. for in this Case m (in the Theorem) is $= 1$, $n = 5$, $P = c^5$, and $Q = \frac{c^4x+c^5}{-x^5}$; or also $-x^5$ may be put for P, and $\frac{c^4x+c^5}{-x^5}$ for Q; then will $\sqrt[5]{c^5+c^4x-x^5} = -x + \frac{c^4x+c^5}{5x^4} + \frac{2c^8xx+4c^9x+2c^{10}}{25x^9}$ + &c. The former Case being to be taken when x is very little, and the latter when *it* is very great. Again, $\frac{N}{\sqrt{y^3-a^2y}} (= N \times \overline{y^3-a^2y}|^{-\frac{1}{2}})$ will be $= N \times \overline{\frac{1}{y} + \frac{aa}{3y^3} + \frac{2a^4}{9y^5} + \frac{14a^6}{81y^7}}$, &c. For $P = y^3$. $Q = -\frac{aa}{yy}$. $m = -1$. $n = 3$. $A\ (P^{\frac{m}{n}} = y^{3 \times -\frac{1}{3}})$ will be $= y^{-1}$, that is $\frac{1}{y}$. $BC\ (= \frac{m}{n}AQ = -\frac{1}{3} \times \frac{1}{y} \times \frac{aa}{yy}) = \frac{aa}{3y^3}$, &c.

Moreover the Cube Root of the fourth Point of $d+e$, (that is, $\overline{d+e}|^{\frac{4}{3}}$) is $= d^{\frac{4}{3}} + \frac{4ed^{\frac{1}{3}}}{3} + \frac{2ee}{9d^{\frac{2}{3}}} - \frac{4e^3}{81d^{\frac{5}{3}}}$ + &c. For $P = d$, $Q = \frac{e}{d}$, $m = 4$, $n = 3$, $A\ (= P^{\frac{m}{n}}) = d^{\frac{4}{3}}$, &c. Also simple Powers may after the same Manner be found, as if the fourth Power of $d+e$ were wanted; that is $\overline{d+e}|^{5}$ or $\overline{d+e}|^{\frac{5}{1}}$ then will $P = d$, $Q = \frac{e}{d}$, $m = 5$, and $n = 1$. And so $A\ (= P^{\frac{m}{n}}) = d^5$. $B\ (= \frac{m}{n}AQ) = 5d^4e$. and $C = 10d^3ee$. $D = 10dde^3$. $E = 5de^4$. $F = e^5$ and $G.\ (= \frac{m-5n}{6n}FQ) = 0$. that is, $\overline{d+e}|^{5} = d^5 + 5d^4e + 10d^3ee + 10dde^3 + 5de^4 + e^5$.

Even Division, whether it be simple or repeated, may be perform'd by this Theorem, as if $\frac{1}{d+e}$ (that is, $\overline{d+e}|^{-1}$ or $\overline{d+e}|^{-\frac{1}{1}}$) be

be to be expanded into a Series, we shall have $P = d$, $Q = \frac{e}{d}$. $m = -1$. $n = 1$. and A $(P^{\frac{m}{n}} = d^{-1})$ $= d^{-1} = \frac{1}{d}$. B $\left(= \frac{m}{n} A Q = 1 \times \frac{1}{d} \times \frac{e}{d}\right) = -\frac{e}{dd}$, and so $C = \frac{ee}{d}$. $D = -\frac{e^3}{d^4}$, &c. that is,

$$\frac{1}{d+e} = \frac{1}{d} - \frac{e}{dd} + \frac{ee}{d^3} - \frac{e^3}{d^4}, \text{ \&c.}$$

From these few Examples the great Use of this wonderful Theorem may, in some measure, appear. But indeed its Uses are almost infinite; comprehending the Method of Indivisibles, the Arithmetick of Infinites, the Doctrine of Series's; and many other Conclusions, wherein Division and the Extraction of Roots are necessary.

Our great Sir *Isaac Newton* first found out this Theorem, and sent it in a Letter, in the Year 1676, to Mr. *Oldenburgh*, the (then) Secretary of the Royal Society, for him to communicate to Mr. *Leibnitz*, as may be seen in a little Book, called *Commercium Epistolicum de varia re mathematica inter celeberrimos præsentis sæculi mathematicos*: But no where tells us his manner of investigating it, nor gives any sort of proof thereof. He says, indeed, in his next Letter to the above-named Mr. *Oldenburgh*, (to be found in the Book but now mention'd) that the Occasion of its Discovery was this:——

" Not long (says he) after I had " ventured upon the Study of the " Mathematicks, whilst I was per- " using the Words of the celebrated " Dr. *Wallis*, (*viz.* the Doctor's " *Arithmetick of Infinites*, see Prop. " 118, 121. of his *Algebra*, Chap. " 8.) and considering the Series of " universal Roots, by the Interpo- " lation of which, he exhibits the " Area of the Circle and Hyper- " bola; for instance, in this Series " of Curves, whose common Base " or Axis is x, and the respective " Ordinates $\overline{1-xx}|^{\frac{0}{2}}$, $\overline{1-xx}|^{\frac{1}{2}}$, " $\overline{1-xx}|^{\frac{2}{2}}$, $\overline{1-xx}|^{\frac{3}{2}}$, $\overline{1-xx}|^{\frac{4}{2}}$, " $\overline{1-xx}|^{\frac{5}{2}}$, &c. I observed that " if the Areas of the alternate Curves " which are x, $x - \frac{1}{3}x^3$, $x - \frac{2}{3}$ " $x^3 + \frac{1}{5}x^5$, $x - \frac{3}{3}x^3 + \frac{3}{5}x^5$ " $- \frac{1}{7}x^7$, &c. could be interpo- " lated, we should, by this means, " obtain the Areas of the interme- " diate ones; the first of which " $\overline{1-xx}|^{\frac{1}{2}}$, is the Area of the " Circle: in order to this; first it " was evident, that in each of these " Series's the first Term was x, that " the second Terms $\frac{0}{3}x^3$, $\frac{1}{3}x^3$, $\frac{2}{3}$ " x^3, $\frac{3}{3}x^3$, &c. were in an Arith- " metical Progression, and conse- " quently the two first Terms of the " Series to be interpolated must be " $x - \frac{\frac{1}{2}x^3}{3}$, $x - \frac{\frac{3}{2}x^3}{3}$, $x -$ " $\frac{\frac{5}{2}x^3}{3}$, &c.

" Now for the Interpolation of " the rest, I considered that the De- " nominators 1, 3, 5, 7, &c. were " (in all of them) in an arithmetical " Progression, and consequently the " whole Difficulty consisted in find- " ing out the numerical Coefficients. " But these in the alternate Areas, " which are given, I observed were " the same with the Figures of which " the several ascending Powers of the " Number 11 do consist, *viz.* 11^0, " 11^1, 11^2, 11^3, 11^4, &c. that is, " first 1; the second 1, 1; the third

" 1,

“ 1, 2, 1; the fourth 1, 3, 3, 1;
“ the fifth 1, 4, 6, 4, 8, *&c.*

“ I apply'd myself therefore (says “ he) to find out a method by which “ the two first Figures of this Series “ might be derived from the rest; “ and I found, that if for the second “ Figure or numerical Term I put m, “ the rest of the Terms will be pro- “ duced by the continual Multipli- “ cation of the Terms of this Series

“ $\frac{m-0}{1} \times \frac{m-1}{2} \times \frac{m-2}{3} \times \frac{m-3}{4}$
“ $\times \frac{m-4}{5}$, *&c.*

“ For instance, if the second Term “ m be put for 4, and there will a- “ rise $4 \times \frac{m-1}{1}$, that is 6; which “ is the third Term. The fourth “ Term will be $6 \times \frac{m-2}{3}$, that is “ 4. $4 \times \frac{m-3}{4} = 1$, is the fifth “ Term; and the sixth is $4 \times \frac{m-4}{1}$ “ $= 0$; which shews the series is “ here terminated in this Case.

‘ This being found, I apply'd it ‘ as a Rule to interpolate the above ‘ mention'd Series; and since in the ‘ Series, which will express the Cir- ‘ cle, the second Term was found to ‘ be $\frac{\frac{1}{2}x^3}{3}$. Therefore I put $m = \frac{1}{2}$, ‘ and there was produced the Terms ‘ $\frac{1}{2} \times \frac{\frac{1}{2}-1}{2}$ or $-\frac{1}{8}$; $\frac{1}{8} \times \frac{\frac{1}{2}-2}{3}$, ‘ or $+\frac{1}{16}$; $+\frac{1}{16} \times \frac{\frac{1}{2}-3}{4}$, or $-$ ‘ $\frac{5}{128}$, and so on *ad infinitum.* Hence ‘ I found that the Area sought of ‘ the Segment of the Circle is $x -$ ‘ $\frac{\frac{1}{2}x^3}{3} - \frac{\frac{1}{8}x^5}{5} - \frac{\frac{1}{16}x^7}{7} -$ ‘ $\frac{\frac{5}{128}x^9}{9}$, *&c.*

‘ In the same manner, the Areas ‘ to be interpolated of the other ‘ Curves might be produced, as ‘ might also the Area of the Hy- ‘ perbola, and the rest of the alter- ‘ nate Curves in this Series ‘ $\overline{1+xx}|^{\frac{0}{2}}$, $\overline{1+xx}|^{\frac{1}{2}}$, $\overline{1+xx}|^{\frac{2}{2}}$, ‘ $\overline{1+xx}|^{\frac{3}{2}}$, *&c.* By the same way ‘ likewise other Series's might be ‘ interpolated, and that too if they ‘ should be taken at the distance of ‘ two or more Intervals.

‘ This was the way by which I ‘ first opened an Entrance into these ‘ Speculations, which I should not ‘ have remember'd, but that in turn- ‘ ing over my Papers a few Weeks ‘ ago, I, by chance, cast my Eyes ‘ upon those relating to this Mat- ‘ ter.

‘ After I had so far proceeded, it ‘ immediately occurr'd to me, that ‘ the Terms $\overline{1-xx}|^{\frac{0}{2}}$, $\overline{1-xx}|^{\frac{2}{2}}$, ‘ $\overline{1-xx}|^{\frac{4}{2}}$, $\overline{1-xx}|^{\frac{6}{2}}$, *&c.* that ‘ is, 1, $1-xx$, $1-2xx+x^4$, ‘ $1-3xx+3x^4-x^6$, *&c.* ‘ might be interpolated in the same ‘ manner as I had done the Areas ‘ generated by them; and for this, ‘ there needed nothing else but to ‘ leave out the Denominators 1, 3, ‘ 5, 7, *&c.* in the Terms that ex- ‘ press the Areas, that is, the Co- ‘ efficients of the Terms of the ‘ Quantity to be interpolated ‘ ($\overline{1-xx}|^{\frac{1}{2}}$, or $\overline{1-xx}|^{\frac{3}{2}}$; or u- ‘ niversally $\overline{1-xx}|^{m}$) will be had ‘ by the continual Multiplication of ‘ the Terms of this Series, $m \times$ ‘ $\frac{m-1}{2} \times \frac{m-2}{3} \times \frac{m-3}{4}$, *&c.*

‘ Thus for example, $\overline{1-xx}|^{\frac{1}{2}} = 1$ ‘ $-\frac{1}{2}x^2 - \frac{1}{8}x^4 - \frac{1}{16}x^6$, *&c.* ‘ and $\overline{1-xx}|^{\frac{3}{2}} = 1 - \frac{3}{2}x^2 -$

$\frac{3}{8}$

' $\frac{3}{8}x^4 + \frac{1}{16}x^6$, &c. and $\overline{1 - xx}|^{\frac{1}{3}}$ ' $= 1 - \frac{1}{3}x^2 - \frac{1}{9}x^4 - \frac{5}{81}x^6$, ' &c.

' Thus I discover'd a general Me- ' thod of reducing radical Quantities ' into infinite Series by the binomial ' Theorem, which I sent in my last ' Letter, before I observed that the ' same thing might be obtain'd by ' the Extraction of Roots.

' But after I had found out that ' Method, this other way could not ' long remain unknown; for, in or- ' der to prove the truth of these O- ' perations, I multiplied $1 - \frac{1}{2}x^2$ ' $- \frac{1}{8}x^4 - \frac{1}{16}x^6$, &c. by itself, ' and the Product is $1 - xx$, all ' the Terms after these *in infinitum* ' vanishing; and so $1 - \frac{1}{3}xx - \frac{1}{9}$ ' $x^4 - \frac{5}{81}x^6$, &c. twice multiplied ' into itself produced $1 - xx$. As ' this was a certain Proof of the ' Truth of these Conclusions, so I ' was thereby naturally led to try ' the Converse of it, *viz.* whether ' these Series's that now were known ' to be the Roots of the Quantity ' $1 - xx$, might not be extracted ' thence, by the Rule for Extraction ' of Roots in Arithmetick; and upon ' trial I found it to succeed accord- ' ing to my Desire.

I shall here set down the form of the Process in Quadratics:

$$
\begin{array}{l}
1 - xc\ (1 - \frac{1}{2}xx - \frac{1}{8}x^4 - \frac{1}{16}x^6, \text{\&c.} \\
\underline{1} \\
0 - xx \\
\underline{\quad - xx + \frac{1}{4}x^4} \\
\qquad\quad - \frac{1}{4}x^4 \\
\qquad\quad \underline{- \frac{1}{4}x^4 + \frac{1}{8}x^6 + \frac{1}{16}x^8} \\
\qquad\qquad\quad - \frac{1}{8}x^6 - \frac{1}{64}x^8, \text{\&c.}
\end{array}
$$

' This being found, I laid aside ' the Method of Interpolation, and ' assumed these Operations as a more ' genuine Foundation to proceed ' upon. In the mean time I was not ' ignorant of the way of Reduction ' by Division, which was so much ' easier.' Thus far the Great *Newton:* who also says, in the same Letter, that the dismal Plague in the Year 1665 made him remove from *Cambridge*, and think of other things. This admirable Theorem, which is put upon his Monument in *Westminster-Abbey*, has never been yet demonstrated, although many able Mathematicians have made various Attempts to come at the Reason thereof. But in my Opinion, they have all fail'd; for all that ever I saw done, on this Subject, amounts to no more than finding the Truth of the Theorem in one Case only, *viz.* when the Exponent of the Binomial is an whole Number, and that either by a kind of Induction, deduced from the Observation of the Series's of the Co-efficients of the several Powers of a Binomial, suppose $a + x$, and the Doctrine of figurate Numbers; or else by the Method of Increments or Fluxions; or some other the like obscure, strain'd, unsatisfactory, and unnatural way. See *Ralphson*'s *History of Fluxions*, *Jones*'s *Synopsis*, *Sterling*'s *Enumeration of the Lines of the third Order*, *Wolfius*'s *Algebra*, *Brook Taylor*'s *Methodus Incrementorum*, *Cunn*'s *Method of Increments*, in this Dictionary under the word *Series*.

The Person aforesaid has also given two Theorems as Rules for reducing Binomials, consisting of rational and surd Quantities, or both surd Quantities, to more simple

Terms where possible. And this you will find at the Beginning of his *Algebra*. They are these: 1. *If* A *expresses the greater part of a Quantity, and* B *the lesser part: then will*

$$\frac{A+\sqrt{AA-BB}}{2}$$ *be the Square of the greater part of the Root; and* $A-\sqrt{AA-BB}$ *the Square of the lesser part, to be added to the greater with the Sign of* B. So that if the Binomial be $3+\sqrt{8}$; (A being $=3$, and B $=\sqrt{8}$) we shall have the square Root of $3+\sqrt{8}=1+\sqrt{2}$. In like manner $\sqrt{32}-\sqrt{24}=\sqrt[4]{18}-\sqrt[4]{2}$. Secondly, *If* $A\pm B$ *be a Binomial, whose greater Part is* A, *and the Index of the Root to be extracted* c, *and* n *be found to be the least Number, whose Power* n^c *can be divided by* $AA-BB$, *without a Remainder, and* Q *be the Quotient: And if*

$$\sqrt[c]{\overline{A+B}\times\sqrt{Q}}$$ *be computed in the nearest integral Numbers, and the same be called* r, *and if* $A\sqrt{Q}$ *be divided by the greatest rational Divisor, and the Quotient be* s, *and if*

$$\frac{r+\frac{n}{r}}{2s}$$ *in the nearest integral Numbers be* t, *then will*

$$\frac{ts\pm\sqrt{ttss-n}}{\sqrt[2c]{Q}}$$ *be the Root whose Index is* c, *provided the Root can be extracted.* So that the cube Root of $\sqrt{968}+25$ will from hence be $2\sqrt{2}+1$. $AA-BB$ being $=343$, its Divisors 7, 7, 7; $n=7$, and $Q=1$. also the Root of the first Part of $\overline{A+B}\times\sqrt{Q}$, or $\sqrt{968}+25$ being extracted, will be a little greater than 56; its cube Root in the nearest Number 4; and so $r=4$. Moreover by extracting all that is rational from $A\sqrt{Q}$ or $\sqrt{968}$, it will be $22\sqrt{2}$: Therefore $\sqrt{2}$ the radical Part of it will be s,

$$\frac{r+\frac{n}{r}}{2s}, \text{ or } \frac{5}{2\sqrt{2}}$$ in the nearest integral Numbers is 2; therefore $t=2$. Lastly, ts is $2\sqrt{2}$.

$\sqrt{ttss-n}$ is 1, and $\sqrt[2c]{Q}$ or $\sqrt[6]{1}$ is 1.

Sir *Isaac Newton* has not thought fit to lay down a Demonstration of these two Theorems, or Rules, which are much more elegant and general than those given us for extracting the Roots of Binomials, in *Van-Schouten*'s *Commentary upon* Des Cartes's *Geometry*. But Mr. *s'Gravesande*, at the latter part of his *Algebra*, has been at the pains to give us a Demonstration of the latter of the said Theorems, judging (I suppose) the former to be so easy, as not to spend time about evincing its Truth. In order to which, he premises eight Lemma's; which are these:

1. If to any Power whose Index is c, be elevated the Binomial $a+b$, and the Terms of this Power alternately taken, (that is, the 1st, 3d, 5th, 7th, &c. and the 2d, 4th, 6th, 8th, &c.) be united into one Sum, and so the whole Power be divided into two Parts; the Difference of the Squares of the Parts will be $\overline{aa-bb}|^c$.

2. If a and b represent Numbers, whereof a is the greater, and the Binomial $\sqrt{a}+\sqrt{b}$ be elevated to the Power c, and this Number be odd, this Power will be a Binomial one of whose Members is multiplied by $\sqrt{a}$, and the other by $\sqrt{b}$; and these Members will be the Parts,

(Lemma

(Lemma 1.) of which the greater is that which is multiplied by $\sqrt{a}$.

3. If the same things being supposed, the Number c be even, the Power forms a Binomial, one of whose Members is rational, and the other multiplied by $\sqrt{ab}$, the Members will be also the Parts mention'd in Lem. 1.

4. Any Power of a numerical Binomial $\sqrt{a} + \sqrt{b}$ has both its Members positive; the Power of a Binomial or Apotome $\sqrt{a} - \sqrt{b}$ has one Member negative; and the Members themselves do not differ, whether it be $+ \sqrt{b}$ or $- \sqrt{b}$.

5. If a Binomial $\sqrt{a} + \sqrt{b}$ be raised to a Power whose Index is c, the Difference of the Squares of the Members of the Power is $\overline{a - b}|^{c}$.

6. The Root of a Binomial whose Index is c, that is $\sqrt[c]{\ }$, cannot be extracted, unless the Difference of the Squares of the Parts of the given Binomial has $\sqrt[c]{\ }$ rational.

7. If two continual decreasing geometrical Progressions have the middle Term common, the Difference between the first Terms of the Progression will be greater than the Difference between the last.

8. The $\sqrt[c]{\ }$ of a Binomial cannot be extracted, if c be an even Number, unless the greater Member of the given Binomial be rational.

BIQUADRATIC EQUATION, in Algebra, is any Equation consisting of not more than four Terms, and where the unknown Quantity of one of the Terms has four Dimensions: As $x^4 + ax^3 + bx^2 + cx + d = o$ is a biquadratic Equation, because the Term x^4 is of four Dimensions.

1. Any biquadratic Equation may be conceiv'd to be generated or produced from the continual Multiplication of four simple Equations, (as if x be $= a$, $x = b$, $x = c$, $x = d$, or $x - a = o$, $x - b = o$, $x - c = o$, $x - d = o$; then will $\overline{x - a} \times \overline{x - b} \times \overline{x - c} \times \overline{x - d} = o$ beget a biquadratic Equation) or, from the Multiplication of one simple Equation, and a cubic Equation, (as $\overline{x - a} \times \overline{x^3 + cx^2 + dx + e} = o$) or lastly, from the Multiplication of two quadratic Equations, as $\overline{x^2 + bx + c} \times \overline{x^2 + dx + e} = o$.

2. Any biquadratic Equation may be reduced to a cubic Equation; by first reducing it to another, wanting the second Term. If the proposed one does not want its second Term, and supposing this last to be produced by the Multiplication of two assumed quadratic Equations, and then finding the Values of the several Co-efficients of these last Equations, express'd in the known Co-efficients of the Terms of the biquadratic Equation; whereby a new Equation will be had, consisting of four Terms, containing only the sixth, fourth, and second Powers of the unknown Quantity, and a known Quantity, which in reality is but a cubic Equation, being reducible thereto by substituting some unknown Quantity for the Square of that in the Equation, wherein the unknown Quantity has six Dimensions. But it must be confess'd that this Operation is long and troublesome in most Cases.

Take the following Example from Sir *Isaac Newton*'s *Algebra*: Let $x^4 + ax^3 + bx^2 + cx + d = o$ be a biquadratic Equation, having all its Terms: transmute the same into another wanting the second; which let be $x^4 + qxx + rx + s = o$. Now let us suppose this Equation to be generated by the Multiplication of

of two quadratic Equations $xx + ex + f = o$, and $xx - ex + f = o$; that is, let it be the same as

$$x^4 \left.\begin{matrix} +f \\ +g \\ -ee \end{matrix}\right\} xx \left.\begin{matrix} +eg \\ -ef \end{matrix}\right\} x + fg = o;$$

then by comparing the Terms together, we shall have $f + g - ee = q$, $eg - ef = r$, and $fg = s$.

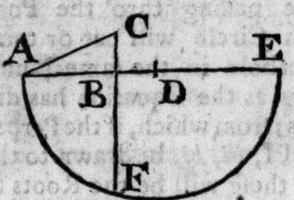
Wherefore $q + ee = f + g$, $\frac{r}{e} = g - f$, $\dfrac{q + ee + \frac{r}{e}}{2} = g$, $\dfrac{q + ee - \frac{r}{e}}{2} = f$, $\dfrac{qq + 2eeq + e^4 - \frac{rr}{ee}}{4} (= fg) = s$; and by Reduction $e^6 + 2qe^4 \begin{matrix} +qq \\ -4s \end{matrix} ee - rr = o$, put y for ee, and then it will be $y^3 + 2qyy \begin{matrix} +qq \\ -4s \end{matrix} y - rr = o$. Find the Root or Roots of this Equation, and putting $\sqrt{y} = e$, $\dfrac{q + ee - \frac{r}{e}}{2} = f$, $\dfrac{q + ee + \frac{r}{e}}{2} = g$, and extracting the Roots of the assumed quadratic Equation $s\,xx + ex + f = o$, $xx - ex + g = o$; their Roots will give the four Roots of the given biquadratic Equation $x^4 + qxx + rx + s = o$, viz. $x = -\frac{1}{2}e \pm \sqrt{\frac{1}{4}ee - f}$, and $x = \frac{1}{2}e \pm \sqrt{\frac{1}{4}ee - g}$. And if the four Roots of the given biquadratic Equation be possible, the three Roots of the cubic Equation $y^3 + 2qyy \begin{matrix} +qq \\ -4s \end{matrix} y - r = o$ above given, will be always possible.

3. In *Descartes*'s *Geometry* there is a very tedious tentative way of finding the Roots of a biquadratic Equation: and another in Sir *Isaac Newton*'s *Algebra* much more elegant and general, extending to Equations of six, eight, and ten Dimensions, which is to find a surd Divisor, whereby to try to divide the Equation into two equal Parts, and then to get the Roots of the Parts.

4. Mr. *Descartes* was the first who has shewn how to find the lineal Roots of cubic, and consequently of biquadratic Equations, (since these last can be always reduced to cubics) by the Intersection of a Circle and Parabola; and after him several others have made Improvements in this Business: Amongst others, see *Baker*'s *Geometrical Key*, *Slusius*'s *Mesolabium*, the *Philosophical Transactions*, N° 188, 190. the Marquis *de l'Hospital*'s *Conic Sections*, *Wolfius*'s *Elementa Matheseos*, &c. For it would be foreign to my Design to be sufficiently particular upon this extensive Subject here; but the Construction of the following biquadratic Equations $x^4 \pm px^2 - q = o$, and $x^4 - px^2 + q = o$ being short, and perhaps useful, may not be displeasing to such who delight in these things. The former of these Equations has always two real equal Roots, one affirmative, and the other negative, and no more; the other two being imaginary: and the latter has two Pair of equal real Roots, when $\frac{1p}{4}$ is less than q.

1. Let it be $x^4 \pm px^2 - q = o$, extract the Root, and then will xx be $= \frac{1}{2}p + \sqrt{q + \frac{1}{4}pp}$; and making $c : \frac{1}{2}p :: \frac{1}{2}p : \sqrt[4]{q}$, we shall have $xx = c\sqrt[4]{q} + \sqrt[4]{q} \times$

$\sqrt{\sqrt{q}+cc}$; and so $x =$
$\sqrt{c+\sqrt{\sqrt{q}+cc}} \times \sqrt{q}$.
Now draw the two right Lines AE, CF, intersecting each other at right

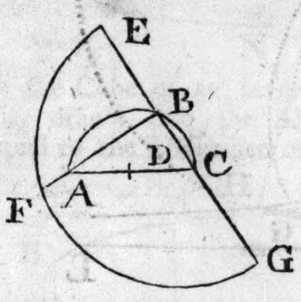


Angles at B, make $AB = \sqrt[4]{q}$, and $BC = c$, join AC, make $BE = AB + BC$, and upon AE describe a Semicircle cutting CF in the Point F, then will BF be $= \pm x$, being the only real Roots of the Equation.

2. Let the Equation be $x^4 - px + q = o$; then in like manner, as above, x will be $=$

$\sqrt{c \pm \sqrt{\sqrt{q}-cc}} \times \sqrt{q}$,

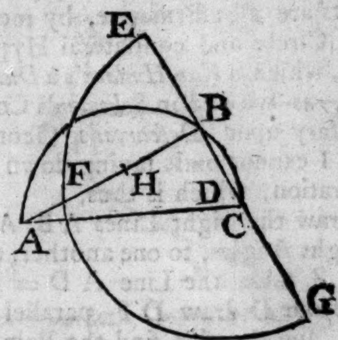
draw $AC = \sqrt[4]{q}$, and upon the same describe a Semicircle ABC;



in which apply $AB = C$, and draw the right Line EBCG thro' B and C; make $CG = AC$ and $BE = AB$ bissect EG in the Point D, and with the Distance DE describe a Semicircle cutting BA (continued) in the Point F; then will $BF = \pm x$ be the greater affirmative or negative Root of the Equation. But

BIQ

to get the lesser affirmative or negative Root, every thing else as before, only make (*fig.* 3.) BE (= AH)



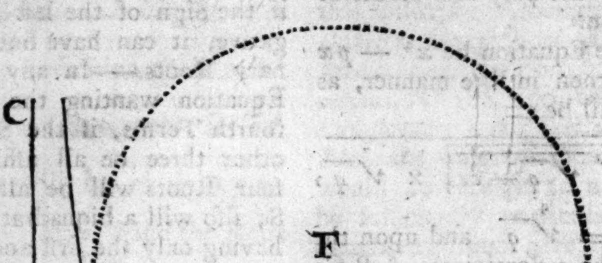
the Difference between AB and DC, and $BG = AC$, and then will $BF = \pm x$ be the lesser affirmative or negative Root of the Equation.

5. In all biquadratic Equations, if the Sign of the last Term be negative, it can have but two imaginary Roots.——In any biquadratic Equation wanting the second and fourth Terms, if the Signs of the other three be all affirmative, its four Roots will be all imaginary. So also will a biquadratic Equation, having only the first and last Terms (when affirmative) have four imaginary Roots.

6. In any biquadratic Equation having all its Terms, if $\frac{3}{8}$ of the Square of the Co-efficient of the second Term be greater than the Product of the Co-efficients of the first and third Terms, or $\frac{3}{8}$ of the Square of the Co-efficient of the fourth Term be greater than the Product of the Co-efficients of the third and fifth Terms, or $\frac{4}{9}$ of the Square of the Co-efficient of the third Term greater than the Product of the Co-efficient of the second and fourth Terms; all the Roots of that Equation will be real and unequal: and if either of the said Parts of those Squares be less than either of those Products, that Equation will have imaginary Roots.

7. Being much pleased with the following elegant Construction of a biquadratic Equation $z^4 - p z^3 + q z z - r z + s = o$. (whose Roots are all affirmative, by means of a Circle and equilateral Hyperbola, which is *Van Hudden*'s a *Dutchman*, as we find in *Schouten*'s Commentary upon *Descartes*'s Geometry) I cannot omit laying down his Operation, which is thus.

Draw the right Lines A B, A C, at right Angles, to one another, and in A B, take the Line $AD = \frac{1}{2} p$, and from D draw D F parallel to A C, and in this find the Point E such, that the Rectangle $AD \times DE$ be equal $\sqrt{s}$, and thro' E describe an equilateral Hyperbola H E *b* about the Asymptotes A B, A C. take $DF = \frac{r}{2\sqrt{s}}$, join A F, and upon A F describe a Semi-circle A D F, and in the same apply $AG = \sqrt{q}$, and about the Centre F describe a Circle passing thro' the Point G, which Circle will cut or touch the Hyperbola in the same Number of Points as the Equation has different Roots; from which, if the Perpendiculars H I, *hi*, *hi*, be drawn to the Line A C, these will be the Roots sought. Where it must be observed, that if A G should be too great to be inscribed in the Semicircle described upon A F, or the Circle G H *b* so small as not to cut or touch the Hyperbola, it is a Sign that all the Roots of the Equation are imaginary.



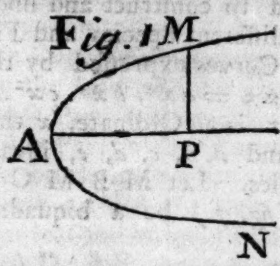
The Demonstration is easy: for supposing $IH = z$, and since $AD \times DE = AI \times IH = \sqrt{s}$, it will be $AI = DK = \frac{\sqrt{s}}{z}$, and $KF = \frac{r}{2\sqrt{s}} - \frac{\sqrt{s}}{z}$, or $\frac{\sqrt{s}}{z} - \frac{r}{2\sqrt{s}}$ and so $KF^2 = \frac{s}{zz} - \frac{r}{z} + \frac{rr}{4s}$

But

But $KH = z - \frac{1}{2}p$, or $\frac{1}{2}p - z$; and so $\overline{KH}^2 = zz - pz + \frac{1}{4}pp$. Wherefore $\overline{FH}^2 = \frac{s}{zz} - \frac{r}{z} + \frac{rr}{4s} + zz - pz + \frac{1}{4}pp$; and since this is $= \overline{AF}^2 = -\overline{AG}^2\, \frac{1}{4}pp + \frac{rr}{4s} - q$, by ordering the Equation we shall have $z^4 - pz^3 + qz^2 - rz + s = 0$.

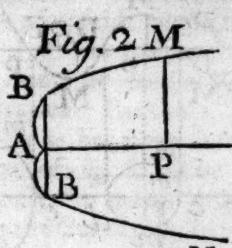
BIQUADRATICAL PARABOLA, is a Curve Line of the third Order, having two infinite Legs A M, A N tending the same way; being of such a Nature, that the Cube of some invariable Quantity, drawn into the Abscis A P (see *fig.* 1.) is equal to the squar'd Square, or fourth Power of the correspondent Ordinate P M;

Fig. 1



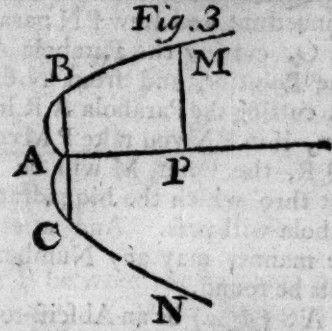
or else the Cube of an invariable Quantity drawn into the Abscis A P equal to the Difference of the

Fig. 2



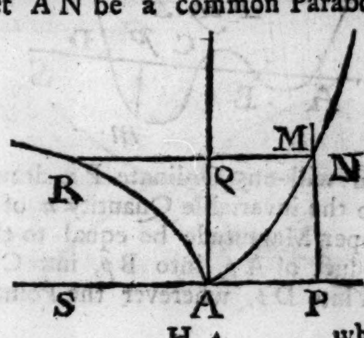
Squares of the correspondent Ordinate P M, and the invariable Line A B, or A C, drawn into the Square of the said Ordinate (see *fig.* 2.) Or lastly, the Cube of an invariable Quantity drawn into the Abscis A P, equal to the Square of the

Fig. 3



correspondent Ordinate A P, *plus* the Rectangle, under the Difference of two invariable, unequal right Lines A B, AC, and the said Abscis, together with the Difference of the Rectangle under these variable Lines, all drawn into the Square of the said correspondent Ordinate, (see *fig.* 3.) That is, supposing A P, x, P M, y, A B, b, A C, c, and the invariable Quantity (whose Cube is drawn into the Abscis) a; the Equations of the Curves will be $a^3x = y^4$, $a^3x = x^4 - aaxx$, $a^3x = x^4 - \overline{a+b} \times x^3 - abxx$.

It is very easy to find Points thro' which one of these Parabola's is to pass, by common Geometry alone, by first resolving the Equation of the Curves into Analogies, and then assuming fourth Proportionals. But more easy still, by means of two common Parabola's. The Way of doing which for the Curve of *fig.* 1. (expressed by the Equation $a^3x = y^4$) being very short, take as follows: Let A N be a common Parabola,



 whose

whose Axis is A Q, and A R another, whose Axis is A S, at right Angles to A Q. Take any Point P in S A, continued out, and draw P N parallel to A Q, cutting the Parabola A N in the Point N, and from N draw N R cutting the Parabola A R in R. Then, if in P N you take P M equal to Q R, the Point M will be one Point thro' the which the biquadratical Parabola will pass. And after the same manner may any Number of Points be found.

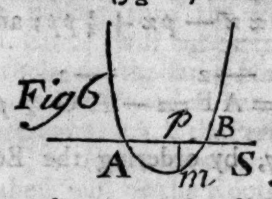
If A S (*fig*.4.) be an Abscis to this

Curve, and the right Lines pm, P M, at right Angles to them be Ordinates, and A p, or A P be called x, and pm, P M, $-y$, $+y$, and a, b, c, d, e, f, are invariable Quantities; then will the Equation $ay = bx^4 . cx^3 . dx^2 . ex . f$. express the Nature of that Curve, or the Relation of each correspondent Abscis A p, A P, and Ordinate pm, P M, being the most general Equation of the Curve possible; and the four Lines A B, A C, A D, A E, are the four Roots of the Equation $o = bx^4 . cx^3 . dx^2 . ex . f$.

If the Beginning of the Abscis A (see *fig*. 5.) be taken in the Curve,

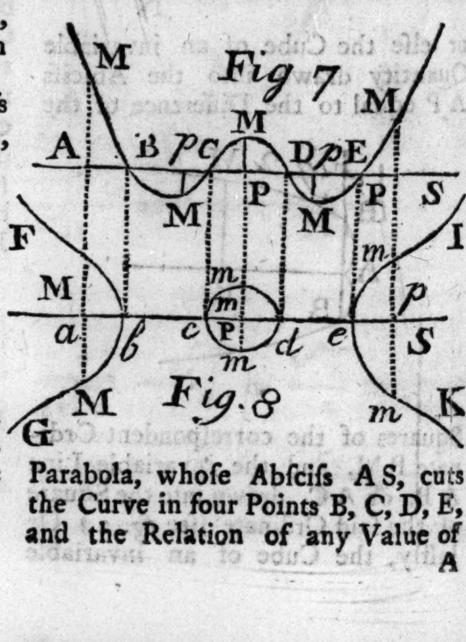
then will any Ordinate P m drawn into the invariable Quantity a of a proper Magnitude be equal to the Product of A p, into B p, into C p, and into D p, wherever the Point p be taken in the infinite Abscis A S whether on this side A, between A, B; B, C; C, D; or beyond D; so that it is an essential Property of the Curve.

If the Curve has no serpentine Part (as that of (*fig*. 6.) the Equation



will then be more simple; for in this Case, it will be $pm \times a = \overline{Ap}^2 \times \overline{pB}^2$. whether the Point p be taken on this side A or beyond B.

This Curve is of much use in constructing many different Curves of the third Order, determining their Numbers, different Species and Figures. For Example, Let it be required to construct and find one of the different Species and Figures of the Curves expressed by the Equation $zz = ax^4 . bx^3 . cx^2 . dx . e$. where z is an Ordinate, x the Abscis, and a, b, c, d, e, invariable Quantities. Let M B M C D M E M (*fig*. 7.) be a biquadratical

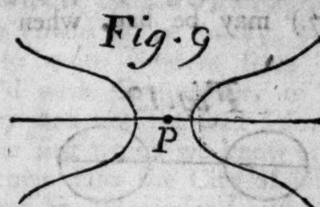


Parabola, whose Abscis A S, cuts the Curve in four Points B, C, D, E, and the Relation of any Value of

AP (x) to the correſpondent Value of PM (y) be expreſſed by the Equation $py = ax^4 . bx^3 . cx^2 . dx\, e.$ p being a given Quantity; this done, draw any abſciſſal Line as parallel to AS, at a convenient Diſtance from it, and from the Points A, B, C, D, E, let fall the Perpendiculars Aa, Bb, Cc, Dd, Ee to as, and taking any Abſciſs AP (in *fig.* 7.) and correſpondent Ordinate PM; continue down PM to cut the Abſciſs as (of *fig.* 8.) in p, and make pm both above and below as, equal to $\sqrt{py}$, or as PM (*fig.* 7.) Then will the Points m, m, be thoſe of the Curve required; and thus may an infinite number of other Points be found. But becauſe PM (y) between B and C, and D, E, are negative, and ſince the ſquare Root of a negative Quantity cannot be taken; it follows that no Part of the Curve wanted, will fall between the Points b, c; and d, e: ſo that the Curve conſiſts of two oppoſite infinite Parts FbG, IeK, with an Oval $cmdm$ between them, having the Line as for a Diameter, and theſe Parts will be Bell-form or diverging Parabola's. And this will always be the caſe when the Equation $o = ax^4 . bx^3 . cx^2 . dx . e$, has four real and unequal Roots, AB, AC, AD, AE, or ab, ac, ad, ae.

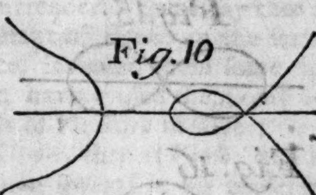
There are five more different parabolic Curves expreſs'd by the Equation aforeſaid, where the greateſt Term ax^4 is Affirmative; all of which may be conſtructed from a biquadratical Parabola, after the ſame way as has been ſhewn already for that of *fig.* 8. The Difference being only, in the abſciſſal Line AS cutting the Curve only in two Points; touching it in two Points, or cutting it in two; touching it in one Point, and cutting it in two; touching it in three Points, and cutting it in one; or not touching it at all: that is, 1. If the Equation $o = ax^4$, $bx^3 . cx^2 . dx . e$, has its two middle Roots equal, the Curve will be that of *Fig.* 9. having a conjugate

Fig. 9



Point P between the oppoſite parabolic Legs. 2. If that Equation has its two leſſer or greater Roots equal, and the other two unequal, the Curve will be that of *fig.* 10. conſiſting of a pure Parabola, and a nodate Parabola.

Fig. 10

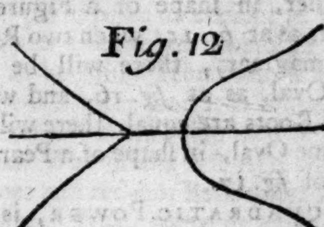


3. If the two middle Roots be imaginary, the Curve will be that of *fig.* 11. conſiſting of

Fig. 11

two pure Parabola's. 4. If three of the Roots be equal, the Curve will have a Cuſpe or triple Point, as that of *fig.* 12.

Fig. 12



So

So likewise by inverting the biquadratical Parabola, (of *fig.* 7.) or turning the Concavity downwards, the five Ovals (*fig.* 13, 14, 15, 16, and 17.) may be had, when the

Fig. 13

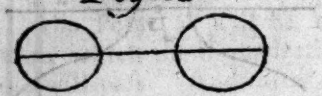


Fig. 14

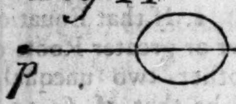


Fig. 15

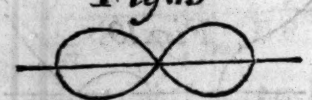


Fig. 16

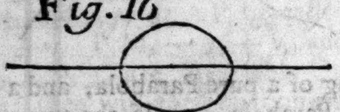
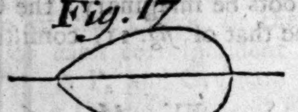


Fig. 17



greatest Term $a x^4$ is negative. For when all the Roots of the Equation are real and unequal, there will be a Pair of Ovals; as at *fig.* 13. when the two greater or lesser Roots are equal, there will be one Oval, and a conjugate Point, as at *fig.* 14. when the two middle Roots are equal, there will be two Ovals join'd together, in shape of a Figure of Eight, as at *fig.* 15. when two Roots are imaginary, there will be but one Oval, as at *fig.* 16. and when three Roots are equal, there will be but one Oval, in shape of a Pear, as that of *fig.* 17.

Biquadratic Power, is the fourth Power, or squared Square of a Number, as 16 is the biquadratic Power of 2; for 2×2 is $= 4$, and 4×4 is $= 16$.

Biquadratic Root *of a Number*, is the square Root of the square Root of a Number, as the biquadratic Root of 81 is 3; for the square Root of 81 is 9, and the square Root of 9 (again) is 3.

Biquintile, an Aspect of the Planets, when they are 144 Degrees distant from each other.

Bissextile, in Chronology, is the same as our *Leap-Year.* And the Reason of the Name is, because in every 4th Year they accounted the 6th Day of the Kalends of *March* twice; for once in four Years the odd Hours, above 365 Days, made up just a whole Day, which was inserted into the Calendar to the 24th of *February.*

Blackness. The Colour so called, seems to arise from such a peculiar Texture and Situation of the superficial Parts of any black Body, that it does, as it were, deaden the Light falling upon it, and reflect none, or very little of it outwards to the Eye.

Sir *Isaac Newton,* in his *Optics,* Book 2. Obj. 4. 17, and 18, shews, That for the Production of Black Colours, the Corpuscles must be less than any of those that exhibit other Colours.

Black Substances, of all others, do soonest become hot, and burn.

Blinds, in Fortification, are certain Pieces of Wood, or Branches of Trees, laid a-cross, from one side of a Trench to the other, to sustain the Bavins or Hurdles laden with Earth; and serve to cover the Pioneers from above; and are commonly used when the Works are carry'd on towards the Glacis, and when the Trench is extended in Front towards the Place.

Blockade, is encompassing any Town,

Town, or Place, so all round with arm'd Troops, that it is impossible for any Supplies to be brought to it; and so it must be starved, or surrender: But there is no design of taking it by Attack, &c. And when any Place is in this Condition, it is said to be *block'd up*, or *blockaded*.

Body, in Geometry, is that which has three Dimensions, Length, Breadth, and Thickness. As a Line is formed by the Motion of a Point, and a Superficies by the Motion of a Line; so a Body is generated by the Motion of a Superficies. But,

Body, in Natural Philosophy, is usually defin'd to be a Substance impenetrably extended, or which having *Partes extra Partes*, cannot be in the same Place with, or penetrate the Dimensions of other Bodies: Which Property Sir *Isaac Newton* expresses by the word *Solidity*; and so the Idea we have of a Body proceeds from its being extended, solid, and moveable.

Bomb-Chest, is a kind of Chest, which, being filled with Gunpowder and Bombs, (according to the intended Execution) is placed under Ground, to blow it up into the Air, together with those that stand upon it.

These Bomb-Chests are frequently used to drive the Enemy from a Post they lately possessed, or whereof they are about to take Possession; and are set on fire by means of a Sausage fasten'd at one End.

Bombs, are hollow Balls of Cast-Iron, which are fill'd with whole Powder, and sometimes Nails, Pieces of Iron, &c. along with it. Their Use is to be shot out of Mortar-Pieces into besieged Towns, to annoy the Garrison, fire Magazines, &c.

The largest are about seventeen Inches in Diameter, two Inches in Thickness, carry 48 Pounds of Powder, and weigh about 490 Pounds.

The Use of Bombs is not very ancient; for altho' we have some mention in History made of certain Fire-Pots, thrown with Engines into the Towns of the Enemy, yet these were quite different from Bombs fill'd with Gunpowder, of which they had not the least Knowledge. The first which we know of, were thrown into the City of *Watchendonck* in *Guelderland*, which was besieged by Count *Mansfield*, under the Command of the Prince of *Parma*, in the year 1588; where the Bombs in a short time, having ruin'd all the Lodgments, so astonish'd the Besieged, that they were obliged to surrender. Some say that an Inhabitant of *Venlo*, in the same Province, invented them some time before, having used them only as Fire-Balls of Pleasure to divert the Duke of *Cleves*, then at *Venlo*: and having thrown several in his presence, one by Misfortune fell into a House, which it fired with so violent and horrible a *Blaze*, that the greatest Part of the City was consum'd before any Help could be gotten. There are some *Dutch* Historians who relate, that a few Months before this Misfortune happen'd, an *Italian* Engineer made some such like Experiments at *Bergenopzoom*, trying to make these Bombs easy and useful in War. But in doing so he was miserably burnt, by the accidental firing off of the Composition which he had design'd for that purpose. Be this as it will, it is very certain that Bombs were not then to be found; altho' the Use of Mortars may perhaps be as ancient as that of Cannon themselves: because there are to be found Iron ones of a very ancient Make; and it is known that several of them were used in the *Italian* War of the last Age, to fling Stones and red-hot Balls to set Towns on fire. Nay, there is even a Design of a Mortar casting forth a Fire-

Ball,

Ball, amongst divers other Pieces of Artillery, mark'd upon the Frontispiece of a Book of *Nicolas Tartaglia* the Mathematician, printed in the year 1538.

The *Spaniards* and *Dutch*, in the long Wars between them, used Bombs and Granado's. And they were first to be found in use amongst the *French*, in the year 1634, at the Siege of *La Motte*. Nor is it Truth, as *Casimir* says in his Book of the great Art of Artillery, that they were in use at the Siege of *Rochelle*. *Lewis* the XIVth of *France* having sent for, from *Holland*, one *Maltus* an *English* Engineer, who had the chief Direction in using them, with much Success, at several Sieges; particularly at *Cohoure*, in the year 1642, he threw one which pierced thro' the Cistern, and obliged the Besieged to surrender much sooner than they would have done, were it not for that Accident. At first he had not all the Experience that he acquired afterwards: for at the Siege of *Landrecy*, in the year 1637, his Battery was in a Redoubt of the *Cardinal de la Vallet*; where they were constantly coming to him and complaining that the Bombs which he design'd to throw into the Place, flew over, and fell beyond the Town, killing a great many People in the Trenches at Mr. *De Candale*'s and *Meilleray*'s Attack, on the other side of the Town. Even at this very Siege a great Misfortune happen'd from him: For once when a great many General Officers had come out of Curiosity to his Battery, he fired off several Bombs in their presence. But at length, having set fire to the Fuzee of a charged Bomb, and then going to set fire to the Touch-hole of the Mortar, he found his Match gone out; and immediately giving the alarm, crying out for every one to take care of himself that could, he jump'd first upon the Parapet of the Redoubt: every body try'd to do the same; but the Confusion and Disorder was so great, that the Bomb burst within the Mortar, and broke it into a thousand Pieces, killing and wounding many People.

But at length, this Engineer himself was killed at the last Siege of *Gravelin*, by a very extraordinary Misfortune; he having pitch'd upon a Post very near the Counterscarp of the Enemy, where he design'd to push his Work as soon as it was dark, and having a desire to shew it to the General Officer, he jump'd up in the Trench to shew him its Situation; the Officer himself did the same after him, but being not sufficiently inform'd of it, he desired that *Maltus* would jump up once more, that so he might have a better Knowledge of it: *Maltus* did so, and at that Instant was shot thro' the Head with a Musquet-Ball.

All this Person's Knowledge consisted in pure Experience, being quite destitute of Mathematical Helps, or any sort of Science that could inform him of the Nature of the Motion of Bombs, and the Curve Line which they describe in their Passage thro' the Air, or the Difference of their Ranges according to the different Elevations of the Mortar; ever directing his Mortar by accident and guess, or rather by the Estimation that he made of the Distance of the Place to which he had a mind to throw the Bomb, according to which he gave it a greater or less Elevation; observing whether the first shots were just or not; and lowering his Mortar, if its range was too short; or raising it, when it fell beyond the Mark; using a sort of a Square for that purpose.

Nicholas Tartaglia the Mathematician, in his Treatise *Concerning a New Science*, says that a Bomb describes a Curve in its Passage with

a Motion partly violent, whose Force constantly decreases, and by a natural Motion constantly increasing. which is false in the Line described by Projectiles; because their Velocity continually decreases.—He thought a good deal upon this Subject, and promised to give us the Order and Proportion of the Shots of Cannon or Mortars, whereby they increase or diminish, according to the Elevation of the Piece; and how to calculate all the different Distances made with the same Charge of Powder, by knowing and measuring only one Distance. But he says afterwards, that as the said Science might contribute to the Ruin and Destruction of Mankind, he was resolved to suppress it; with this Reserve nevertheless, to communicate the same *viva voce* to those who were desirous of serving it against the Infidels.—He was the first who observed that it was impossible for any part of the Path of a Projectile to be a right Line.—That the greatest Range was at the Elevation of 45 Degrees, and the Gunners of his Time thinking that the greatest Range was at 30 Degrees, he undeceived them both by his Doctrine and Experience; and a Wager was laid about it at *Verona*, in the year 1532, where a 24 Pound Culverin, loaded equally with Powder and Ball, was discharged at an Elevation of 45 Degrees, and an Elevation of 30 Degrees, affirming that he was not indeed present at the Experiment, but what he says of the Length of each Range, was only by the Report of others, who told him that the Range at the Elevation of 45° was 1972 Perches of *Verona*, and that at the Elevation of 30° was 1872 of those Perches; and makes the following Reflection upon it, that in the Computation of those two Numbers, one of these three things must happen, *viz.* that the Measures of the Ranges were not exactly taken, or falsely related to him, or else the Piece for the second Discharge was loaded with more or better Powder than at the first; because, says he, Reason shews that the Range of the second Discharge must not be so great in proportion to the first. And in this, indeed, *Tartaglia* is in the right: for if the first Range made from the Elevation of 45° is 1972 Perches, the other from the Elevation of 30° must be but 1710 Perches.

Don *Diego Ufano*, a *Spanish* Captain of Artillery (who long served in the Wars in *Flanders*, and particularly at the Siege of *Ostend*, in the year 1611, in a Book of Gunnery published by him) is the first who observed that the Ranges of Balls or Bombs, shot with equal Charges of Powder from Cannon or Mortars, at Elevations equally above or below 45 Degrees, are equal.—He also makes the Path of a Ball or Bomb in its flight to consist of two right Lines and a Curve: for he makes its Motion to be threefold, the first of which he calls violent, is along a right Line; the second, which he calls mixt, is along a Curve; and the third, which he calls a pure and natural Motion, is also along a right Line; that is, he supposes the Force of the Powder communicates a Motion to the Bomb, carrying it along a right Line in the Direction of the Mortar, as long as that Force continues considerable; but when it begins to abate, it is ballanced by the Weight of the Bomb, its Direction is alter'd, and becomes a Curve, by the Mixture of the two Impresses. And this Curve deviates into an upright streight Line, when the Weight being overcome, and the Force impress'd by the Powder quite lost, it is at liberty to carry the Bomb in a right Line directly towards the Centre of the Earth, and upon this Sentiment he has calculated a Table of the Ranges of Bombs to every

Degree

Degree of Elevation. But they are not exactly true.

Bonnet, in Fortification, is a certain Work raiſed beyond the Counterſcarp, having two Faces, which form a Saliant-Angle, and, as it were, a ſmall Ravelin, without any Trench. The Height of this Fortification is three Foot; and it is environ'd with a double Row of Paliſadoes, ten or twelve Paces diſtant from each other. It has a Parapet three Foot high, and is like a little advanced *Corps de Gard*.

Bonnet a Prestre, or the *Prieſt's-Cap*, in Fortification, is an Outwork, having at the Head three Saliant-Angles, and two inwards; and differs from the double Tenaille only in this, that its Sides, inſtead of being parallel, are made like a Swallow's Tail, that is, narrowing, or drawing cloſe at the Gorge, and opening at the Head.

Boötes, the Name of a Northern Conſtellation of the Fixed Stars; of which one, in the Skirt of his Coat, is called *Arcturus*, and is of the firſt Magnitude. This Conſtellation is called *Arctophylax*, and conſiſts of thirty-four Stars.

Boreal Signs, are the ſix firſt Signs of the Zodiac, or thoſe on the Northern Side of the Equinoctial.

Bosphorus, in Geography, is a long narrow Sea, running in between two Lands, by which two Continents are ſeparated, and by which way a Gulph and a Sea, or two Seas, have a Communication one with another, as the *Thracian Boſphorus*, now called the *Streights of Conſtantinople*.

Bow, a Mathematical Inſtrument, made in Wood, formerly uſed by Seamen, to take the Altitude of the Sun, but now is out of uſe; and conſiſts of a large Arch of 90 Degrees, three Vanes, and a Shank or Staff.

Bow, alſo is a Beam of Wood, or Braſs, with three long Screws, that govern or bend a Lath of Wood or Steel to any Arch; and is of great Uſe for drawing Arches, that have large Radii, &c. which cannot be ſtruck with Compaſſes.

Boultine, in Architecture, is the Workmen's Term for a Convex Moulding, whoſe Convexity is juſt $\frac{1}{4}$ of a Circle. This is placed next below the Plinth in the *Tuſcan* and *Dorick* Capital.

Box and Needle, is the ſmall Compaſs of a Theodolite, Circumferentor, or Plain-Table.

Boyau, *or Branch of the Trenches*, in Fortification, is a particular Ditch ſeparated from the main Trench, which in winding about encloſes different Spaces of Ground, and runs parallel with the Works and Fences of the Body of the Place; ſo that when two Attacks are made near one to another, the *Boyau* ſometimes makes a Communication between the Trenches, and ſerves as a Line of Contravallation, not only to hinder the Sallies of the Beſieged, but alſo to ſecure the Miners. But when it is a particular Cut, that runs from the Trenches to cover ſome Spot of Ground, it is then drawn parallel to the Works of the Place, that it may not be enfiladed, that is, that the Shot from the Town may not ſcour it.

Brace, in Architecture, is a Piece of Timber framed in with Bevil-Joints, and is uſed to keep the Building from ſwerving either way. When a Brace is fram'd into the Kindleſſes, and principal Rafters, it is called by ſome a *Strut*.

Brackets, in Gunnery, are the Cheeks of the Carriage of a Mortar. They are made of ſtrong Planks of Wood of almoſt a ſemicircular Figure, and bound round with thick Iron Plates. They are fixed to the Bed

Bed by four Bolts, which are called *Bed-Bolts*; they riſe up on each ſide of the Mortar, and ſerve to keep her at any Elevation, by means of ſome ſtrong iron Bolts, called *Bracket-Bolts*, which go thro' theſe Cheeks or Brackets.

BRANCH *of the Trenches.* See *Boyau*.

BREACH, in Fortification, is the Ruins that are made in any Part of the Works of a Town, &c. by playing Cannon, or ſpringing of Mines, in order to ſtorm the Place, or take it by Aſſault.

BREAK GROUND, in Fortification, ſignifies to begin the Works for carrying on the Siege about a Town or Fort.

BREAST SOMMERS, in a Timber Building, are the Pieces in the outward Parts of it, and in the Middle Floors, (not in the Garret and Ground-Floor,) into which the Girders are fram'd.

BREAST-WORK, the ſame with *Parapet*.

BRIDGE *of Communication*, is a Bridge made over a River, by which two Armies, or Forts, that are ſeparated by that River, have a free Communication one with another.

BROKEN RAY, or *Ray of Refraction*, in Dioptrics, is a right Line, whereby the Ray of Incidence changes its Rectitude, or is broken in croſſing the ſecond Medium, whether it be thicker or thinner.

BURNING GLASSES are convex or concave Glaſſes, commonly Spherical, that being expoſed directly to the Sun, do collect all the Rays of the Sun falling upon them into a very ſmall Space, called the *Focus*, diſtant from the Glaſs in the Axis thereof, where Wood, or any other combuſtible Matter being put, will be ſet on fire. Metalline Concaves, that produce this Effect by Reflection, are called *Burning Concaves*.

The Breadth of one of theſe Concaves, if it be the Segment of a great Sphere, muſt not exceed an Arch of eighteen Degrees; and if a Segment of a ſmall Sphere, at moſt, an Arch of thirty Degrees.

Kircher, in Arte Magna Lucis & Umbræ, lib. 10. part 3. c. 1. ſays, That he found by Experience, that the beſt Burning Concaves were ſuch that did not exceed an Arch of eighteen Degrees in their Breadth.

If the Segments of a greater and a leſſer Sphere lie each eighteen Degrees in Breadth, or even ſomething greater or leſs, the Number of Degrees in both being the ſame, the Effects of the greater Segments will be greateſt.

Burning Glaſſes, that are Segments of a greater Sphere, do burn at a greater Diſtance than thoſe that are Segments of a leſſer Sphere.

Schottus, in Magia Univerſ. part 1. lib. 7. ſect. 6. p. 1418. ſays, That one *Manfredus Septala*, at *Milan*, made a parabolic Speculum of this kind, that would burn Wood at the Diſtance of fifteen or ſixteen Paces.

Mr. *Villette*, at *Lyons* in *France*, made a metalline Burning Concave of a round Figure, thirty Inches in Diameter, and about a hundred Pound Weight, the Focus, or burning Point, being diſtant from the Concave about three Foot, and its Bigneſs about half a *Louis d'Or*. This would melt Iron in forty Seconds, Silver in twenty-four, Copper in forty-two; and turned Quarry Stone into Glaſs in forty-five, and Mortar in fifty-three Seconds; and melted a Piece of Watch-Spring in nine Seconds. See the *Philoſophical Tranſact.* N° 6. pag. 418. and the *Diary of the Learned at* Paris, *Ann.* 1679.

Mr. *Villette* afterwards made another of thirty-four Inches in Diameter, that would melt all ſorts of Metals of the thickneſs of a Crown-

piece in leſs than a Minute, and vitrify Brick in the ſame time. *Philoſoph. Tranſact.* N°. 49.

In the *Philoſoph. Tranſ.* N°. 188. and the *Acta Eruditorum Ann.* 1687. p. 52. you have mention'd a Copper Burning-Concave, made at *Luſace* in *Germany*, of near three *Leipſick* Ells in Diameter, and its Focus two Ells off, being ſcarce twice ſo thick as the back of a common Knife, and whoſe force is incredible; for a piece of Wood put in the Focus, flames in a moment ſo as it can hardly be put out by a freſh Wind. A piece of Lead or Tin three Inches thick, will be melted quite through in three Minutes time. A piece of Iron or Steel is preſently red hot, and ſoon after hath a Hole burnt through it. Copper, Silver, &c. applied to the Focus, melt, and the Iron aforeſaid will melt in five or ſix Minutes. Slate, in a few Minutes, will be turn'd into black Glaſs. Tiles and Earthen Potſheds, in a little time, do melt into Glaſs. Bones are turn'd into black Glaſs, and a Clod of Earth into greeniſh Glaſs.

Mr. *Tſchirnhauſe* is ſaid to have made Convex Burning-Glaſſes of three or four Feet in Diameter, and whoſe Focus is twelve Feet diſtant, and of an Inch and a half in Diameter; and to make this Focus yet ſtronger, he contracts it by a ſecond *Lens*, placed parallel to, and at a due diſtance from the firſt, and ſo makes the Focus but eight Lines in Diameter. This Glaſs vitrifies Tiles, Slates Pumice-ſtones, &c. in a moment. It melts Sulphur, Pitch, and all Roſins, under Water. Any Metal expoſed to it, in little Lumps upon a Coal, melt in a moment, and Iron ſparkles as in a Smith's Forge. All Metals vitrify on a piece of *China* Plate, if it be not ſo thin as to melt itſelf; and Gold, in vitrifying, receives a purple Colour. See *L'Hiſtoire de l'Academie des Sciences*, Ann. 1699.

Sir *Iſaac Newton* preſented a Burning-Glaſs to the Royal Society, conſiſting of ſeven Concave Glaſſes, ſo placed, as that all their Foci join in one phyſical Point. Each Glaſs is about eleven Inches and a half in Diameter: Six of them are placed round the ſeventh; to which they are all contiguous, and they compoſe a kind of Segment of a Sphere, whoſe Subtenſe is about thirty-four Inches and a half; and the Central-Glaſs lies about an Inch further in than the reſt. The common Focus is about twenty-two Inches and a half diſtant, and of about half an Inch in Diameter. This Glaſs vitrifies Brick or Tile in a Moment, and in about half a Minute melts Gold.

A certain Artificer of *Dreſden* is ſaid to have made very large Burning-Concaves of Wood, whoſe Effects were little inferior to thoſe of the Burning-Speculums of Mr. *Tſchirnhauſe.*

Zahn, in Oculo. Artific. Fundam. 3. *Syntagm.* 3. cap. 10. f. m. 634. ſays, That one *Newman*, in the Year 1699, at *Vienna*, made a Burning-Speculum of ſtiff Paper and Straw glued to it.

And *Zacharias Traberus, in Nervo Optic.* lib. 2. c. 12. prop. 5. cor. 2. ſays, That very large Burning Speculums may be made of thirty, forty, or more Concave Speculums, or ſquare Pieces of Glaſs, conveniently placed in a large turn'd wooden Concave, or Diſh, and that their effect will not be much leſs than if the Superficies were contiguous.

Burning Zone. See *Zone.*

Butments, in Architecture, are the Maſons and Bricklayers Term for thoſe Supports or Props, on or againſt which the Feet of Arches reſt: Alſo little Places taken out of the Yard of the Ground-Plot of a Houſe for a Buttery, Scullery, &c. are ſometimes called Butments.

Buttress,

Buttress, is an Arch, or Mass of Stone, serving to support the Sides of a Building, Wall, &c. on the outside, and are chiefly used in such Buildings as are of the Gothick kind.

Byquartile, the same with *Biquartile*.

C.

Cadence or *Close*, in Music, is a conclusion of a Piece of Music, in some Keys it is not set in: and in long Pieces of Music there are several Cadences. The more there are, the pleasanter is the Music, provided they are artfully disposed.

Caisson, or *Superficial Fourneau*, is a wooden Case, or Chest, into which three, four, five, or six Bombs are put, according to the Execution they are to do, or as the Ground is firmer or looser. Sometimes the Chest is only fill'd with Powder: When the Besieg'd dispute every Foot of Ground, this Caisson is buried under some Work the Enemy intends to possess himself of; and when he is Master of it, they fire it by a Train convey'd by a Pipe, and so blow them up.

Calculus Differentialis, is the Arithmetic of the infinitely small Differences between variable Quantities, and is by us in *England* call'd *Fluxions*.

Mr. *Leibnitz*, about the Year 1676, by most of the Foreigners, is allow'd to have first invented this Doctrine of infinitely small Quantities, who called it the *Calculus Differentialis*; but it is plain, from Sir *Isaac Newton*'s Papers, that Sir *Isaac* was the first Inventor of it, who being too free in communicating it to Mr. *Leibnitz*, he stole it from him; and that the Suspicion might be the less, he invented different Words and Notes from those in Sir *Isaac*'s Method; as for the Fluxion of x, he puts dx; and for y, dy; and these are used by almost all the Foreigners. Yet even *James Bernoulli*, in the *Leipsick* Acts for *January* 1691, owns, that our famous Dr. *Barrow* (before Sir *Isaac*, or *Leibnitz* either,) had given some Specimens of this Method, above ten Years before that Date, in his Geometrical Lectures, and of which all his Apparatus of Propositions there contain'd, are so many Examples. He also acknowledges, that Mr. *Leibnitz*'s Method of the *Calculus Differentialis* is founded upon Dr. *Barrow*'s, and differs from it only in some Notes and compendious Abridgments.

But to give a full and more particular account of the Origin of this great Invention, take what follows from Sir *Isaac Newton* himself, being part of his Remarks upon Mr. *Leibnitz*'s Letter to the *Abbé Conti*; wherein this last endeavours to vindicate his own Conduct about the Invention of the *Calculus Differentialis*: which Remarks, together with Letters of Mr. *Leibnitz*, Sir *Isaac Newton*, Dr. *Clarke*, &c. are contain'd in a *French* Treatise entitled, *Recueil de diverses Pieces sur la Philosophie, la Religion naturelle, l'Histoire, les Mathematiques*, &c.

Sir *Isaac*, speaking of Mr. *Leibnitz*, mentions, that at his Arrival at *London* from *Paris*, his first Letter turn'd chiefly upon other Subjects than Geometry, which lasted till Mr. *Huygens* had instructed him in these matters; that he found out the *Arithmetical* Quadrature of the Circle, towards the end of the Year 1673; that the following Year he began to write thereof to Mr. *Oldenburgh*; that a little while after, he discovered the general Method of Series's from the Assumptions

of an arbitrary one, and the *Calculus Differentialis* in the Year 1676. which he deduced from a Series of Numbers by considering the Differences; and that in his Letter of the 27th of *August*, 1676, he meant by the Words *Certa Analysi*, the *Differential Analysis*. But, says Sir *Isaac*, have not I the same liberty to affirm and certify, that I invented the Method of Series's and Fluxions in the Year 1665; that I carried them farther in the Year 1666; that I have now in my hands several Mathematical Papers, wrote in the Years 1664, 1665, and 1666; some of which are dated? Amongst which there is one, dated the 13th of *November*, 1665. containing the direct Method of Fluxions, in these Words. PROB. *There being given an Equation, expressing the Relation of several Lines, x, y, z, &c. described at the same time by two or more Moveables,* A, B, C, *&c. to find the Relation of their Velocities p, q, r, &c.*

The Solution. 'Put all the Terms 'on one side of the Equation, so 'that they be equal to o; and mul'tiply each by so many times $\frac{p}{x}$, 'as x has Dimensions in that Term: 'then multiply each Term by as 'many times $\frac{q}{y}$ as y has Dimen'sions in that Term: After this 'multiply each Term by as many 'times $\frac{r}{z}$ as z has Dimensions in 'that Term, &c. and the Sum of 'those Products will be $= o$; which 'Equation gives the Relation of 'p, q, r, &c.'

I may add (says Sir *Isaac*) that the said Example is therein illustrated with several Examples; that it is demonstrated therein; that it is there applied to the Solution of Problems relating to the Tangents and Curvatures of Curves: That in another Paper, dated the 16th of *May* 1666, there are seven Propositions, concerning a general Method of resolving Problems relating to Motion, and that the last of these Problems is the same as the Problem abovementioned, dated the 13th of *November* 1665. That in a little Treatise wrote in *November*, 1666, the said seven Propositions are again repeated, with this Difference, that the seventh is carried so far, as not to be limited by Fractions or surd Quantities, or even by what are now call'd Transcendent Quantities; that an eighth Proposition is added to this Treatise, containing the inverse Method of Fluxions, as far as I had advanced it at that time, *viz.* so far as it can depend upon the Quadrature of curv'd-lin'd Spaces, and the three Rules upon which is founded my *Analysis per Æquationes Numero Terminorum infinitas*, and the most part of the other Theorems, contained in the *Scholium* of the tenth Proposition of my Book of Quadratures; that in the said Treatise, when the Area arising from some one of the Terms of the Ordinate, cannot be expressed by the common Analysis, it is represented by writing the Mark $\square$ before that Term. For Example, if the Abscis be x, and the Ordinate $ax - b + \frac{bb}{a+x}$, the whole Area is $\frac{1}{2}ABC - bx + \square \frac{bb}{a+x}$; that in the said Treatise I sometimes use Letters mark'd with one Point only, to represent Quantities that involve first Fluxions; and sometimes the same Letters, mark'd with two Points, representing second Fluxions; that a more compleat Treatise, which I wrote in the Year 1671,

1671, and mention'd in my Letter of the 24th of *October* 1676, is founded upon that little Treatise, and begins with the Reduction of finite Quantities into infinite Series's, and with the Solution of these two Problems; 1. *The Relation of flowing Quantities to one another being given, to find the Relation of the Fluxions.* 2. *And an Equation being given, involving the Fluxions of Quantities, to find the Relation of the Quantities between themselves.*

And when I had wrote that Treatise, I made my Analysis so general, by means of the Method of Series's and the Method of Fluxions conjointly, that it even extended to almost all sorts of Problems; which is what I mention'd in my Letter of the 13th of *June*, 1676. and it is that very Method which I have described in my Letter of the 10th of *December*, 1672.

In the Year 1684. Mr. *Leibnitz* published only the Elements of the *Calculus Differentialis*, which he has applied to some Questions concerning Tangents, and other things relating to the Method of *Maximums* and *Minimums*, as Mr. *Farmat* and *Gregory* had done before; and has shewn how to proceed in these kinds of Questions, without taking away the irrational Quantities; but does not meddle with the Problems of the higher Geometry. The Book of *Mathematical Principles* contains the first public Specimens of the Solutions of the more elevated Problems by this *Calculus*; and it is in this sense I understand what Mr. *Leibnitz* says in the *Leipsick* Acts for the Month of *May*, 1700, pag. 206. But Mr. *Leibnitz* would have it observed, that what he said then must be understood of a particular Artifice of *Maximums* and *Minimums*, which he owns I was master of, by giving in my *Principia*, the Figure of the Vessel or Solid of the least Resistance. But because this Artifice supposes the differential Method as known, and that its Extent is still farther; that besides, it is to this Artifice that Mr. *Leibnitz* and his Scholars owe the Solution of the Problems, which he so much esteems; finally, because Mr. *Leibnitz* calls this Artifice a Method of the highest consequence, and the greatest extent; it is sufficient for me, that he has own'd that I am the first Person, who, in a publick Work, has made it appear that I knew of the said Artifice.

In the Year 1689. Mr. *Leibnitz* publish'd as his own, the principal Propositions of the *Principia*, in three different Writings, entitled, *Epistola de Lineis Opticis*; *Schediasma de Resistentia Medii & Motu Projectilium gravium in medio resistente*; & *Tentamen de Motuum Cœlestium Causis*: pretending that he had found out all those Propositions before the *Principia* appear'd; and in order the better to appropriate to himself the principal of those Propositions he thought fit to subjoin a Demonstration thereto, which he had found out; but as it was erroneous, he retracted it himself, and shew'd that he did not understand how to work with second Fluxions. This here was the second Essay given to the publick, wherein the Method of Fluxions is applied to the higher Geometry. Hitherto this Method was but a little known, but in a Year or two after it began to spread abroad.

Dr. *Barrow* published his Differential Method for Tangents in the Year 1670. Mr. *Gregory*, by means of this Method compared with his own, deduced a general Method for drawing Tangents, which did not require any Calculation; and of this he inform'd Mr. *Collins* by a Letter, wrote the 5th of *September*

tember 1670. and in *November* in the Year 1672. Mr. *Slusius* inform'd Mr. *Oldenburgh* of a Method of his of the same nature. In one of my Letters of the 10th of *December*, 1672, I sent a like Method to Mr. *Collins*, and added, that I mention'd the same to Dr. *Barrow*, at the time of his publishing his *Geometrical Lectures*; that I was of opinion that the Methods of *Gregory* and *Slusius* were the same as mine, and that the said Method was only a Branch or Corollary of a much more general Method, which without any troublesome Calculation, extended not only to drawing Tangents, but likewise other more abstruse Problems; such as those relating to the Curvatures, Areas, Lengths, Centres of Gravity, of Curves, &c. and that without any necessity of freeing Equations from surd Quantities. I added likewise, that I had subjoin'd the Method of Series's to the said Method, meaning in the said Treatise which I wrote in 1671.

Mr. *Oldenburgh*, in *June* 1676. sent Copies of these two Letters amongst the Extracts of *Gregory*'s Letter to Mr. *Leibnitz*; and Mr. *Leibnitz* in his Letter of the 21st of *June*, 1677, sent nothing back in exchange, but what had been done before, and of which the said Letters informed him: His Method of Tangents, which he sent at that time, being only the Method of Dr. *Barrow*, which he disguised under a new Notation, and extended it to *Gregory*'s and *Slusius*'s Method of Tangents, to Equations involving irrational Quantities, and to one of the most simple Cases of my Quadratures. But I cannot be reproach'd of the same thing with regard to Dr. *Barrow*; he saw my Treatise of *Analysis* in 1669. and has testified that he read it; and before his *Geometrical Lectures* appear'd, I did deduce Mr. *Gregory*'s and *Slusius*'s Method of Tangents from my general Method. At that time Mr. *Leibnitz* was not only ignorant of the higher Geometry, but even Algebra itself.

In his Letter of the 27th of *August* 1676, is contained this Passage: *It does not appear to me, what we find is said, that most Difficulties (except the Diophantean Problems) may be reduced to infinite Series's; for there are many Problems so very knotty and intangled, as not to depend upon either Equations or Quadratures, some of which (amongst many others) are the Problems of the inverse Method of Tangents.* But when I made answer to him, that such kind of Problems were in my power to solve, he reply'd in his Letter of the 21st of *June* 1677, that I truly must mean by infinite Series's, but that he meant by common Equations; to which may be seen an Answer in the *Commercium Epistolicum*, pag. 92.

He says, that one might judge that when he wrote his Letter of the 27th of *August* 1676, he had made some entrance into the *Differential Calculus*, since in that Letter he shews how to solve Mr. *Beaune*'s Problem by a *certain Analysis*; but says he, how can it be supposed to solve the same *by a certain Analysis*, without the help of the *Differential Calculus*? For all the Analysis in doing this, is only to suppose the Ordinate of the Curve, to increase or decrease in a Geometrical Progression, while the Abscisse increases in an Arithmetical one, and consequently the Abscisse and Ordinate have the same relation to one another, as the Logarithm to its Number. But, for Mr. *Leibnitz* to infer from hence, that he had made an entrance into the *Calculus Differentialis*, is the very same thing as to say *Archimedes* had made advances

advances that way, becauſe he knew how to draw Tangents to the Spiral, Square of the Parabola, and found out the Proportion of the Sphere and Cylinder, or the ſame thing as to ſay, that *Cavallerius*, *Fermat*, and *Wallis*, had made an entry into it, becauſe theſe have done many things of the ſame nature with thoſe above-mentioned.

Thus far the great *Newton*. Thoſe who have a mind to ſee more of the Hiſtory of this Invention, its various Improvements, and the Uſes thereof, may conſult the *Commercium Epiſtolicum* (publiſh'd by Order of the Royal Society).—— The Marquis *de l'Hoſpital*'s *Analyſe des Infiniment Petits* (in *French* or *Engliſh*).—Mr. *Nieuwentiit*'s *Analyſis Infinitorum*, in *Latin*.— Mr. *Craig*'s *Calculus Fluentium*, in *Latin*.— Mr. *Carré*'s *Methode pour la Meſure des Surfaces*, &c. in *French*.— *Hayes*'s Fluxions, in *Engliſh*.— Mr. *Ditton*'s Fluxions, in *Engliſh*.—Mr. *Reyneau*'s *Analyſe Demontrée*, in *French*.— Dr. *Cheyne*'s *Methodus Inverſa Fluxionum*, in *Latin*.—Sir *Iſaac Newton*'s Fluxions, in *Engliſh*; with, or without Mr. *Colſon*'s Commentaries.——Dr. *Harris*'s Fluxions, in *Engliſh*—Mr. *Muller*'s Mathematical Treatiſe, in *Engliſh*.—Mr. *Hudſon*'s Fluxions, in *Engliſh*.—Mr. *Jones*'s Synopſis, in *Engliſh*.—Mr. *Simpſon*'s Fluxions, in *Engliſh*.—The Philoſophical Tranſactions of *London*, *Paris*, *Leipſick*, *Petersburgh*, &c. and other Writings.

Calculus Exponentialis, is the manner of finding the Fluxions; and of ſumming up of the Fluxions of Exponential Quantities.

This *Calculus* was diſcovered by Mr. *John Bernoulli*, and communicated to Mr. *Leibnitz*, who made it public in the *Acta Eruditorum* for the Year 1697, pag. 125, *& ſeq.* But notwithſtanding the great value ſome People may perhaps put upon this Invention, yet I could never yet ſee any valuable Uſes that have hitherto been made of it.

Calculus Integralis, is the method of finding the proper flowing Quantity of any given Fluxion, and is the reverſe of the *Calculus Differentialis*, which finds the Fluxion from the flowing Quantities.

Calendar, much the ſame as Almanac; which ſee. The Word *Calendar* ſeems to come from the *Calendæ*, which, among the *Romans*, were the firſt Days of every Month.

There have been many Corrections and Alterations of the Calendar. The firſt was made by *Numa Pompilius*; and this afterwards was much improv'd by *Julius Cæſar*, and was by him called the *Julian Account*, which, in our Nation, and ſome other Places, is ſtill retain'd, and called the *Old Style*.

Pope *Gregory* XIII. pretended to reform it again, and ordered his Account to be current, as it is ſtill in all the Roman Catholick Countries, where it is called the *Gregorian Calendar*; and with us *New Style*. It begins eleven Days before ours.

Calendar (Astronomical.) See *Aſtronomical Calendar*.

Calends; ſo the *Romans* called the firſt Days of every Month, from the *Greek* Word *Caleo*, to call; becauſe anciently counting their Months by the Motion of the Moon, there was a Prieſt appointed to obſerve the times of the New Moon; who, having ſeen it, gave notice to the Preſident over the Sacrifices, and he called the People together, and declared to them how they muſt reckon the Days until the Nones; pronouncing the Word *Caleo* five times if the Nones did happen on the 5th Day, or ſeven times if they happened on the 7th Day of the Month.

Caliber, or Caliper, is the Bigneſs, or rather Diameter of a

Piece of Cannon, or any Fire-Arms at the Mouth.

CALIPERS, is an Instrument made like a Sliding-Rule, to embrace the two Heads of any Cask to find the Length of it. There are also *Calipers*, or *Caliper-Compasses*, which are used by Gunners, with crooked or bowing Legs, to measure the Diameters of Bullets and Cylinders of Guns, *&c.*

CALLIPIC PERIOD, was an Improvement of the Cycle of *Meton* of nineteen Years, which *Callipus*, a famous *Grecian* Astronomer, finding in reality to contain nineteen of *Nabonassar*'s Years, four Days, and $\frac{331}{459}$, he, to avoid Fractions, quadrupled the Golden Number, and by that means made a new Cycle of seventy-six Years; which time being expired, he supposed the Lunations, or Changes of the Moon, would happen on the same Day of the Month and Hour of the Day, that they were on seventy-six Years before.

CAMBER-BEAM, in Architecture, is a Beam or piece of Timber cut hollow, or arching in the middle. They are used in Platforms, Church-Leads, *&c.* and are very proper where-ever is occasion for long Beams, being much stronger than flat Beams of the same size; for being laid with the hollow side downwards, and having good Butments at the ends, they serve for a kind of Arch.

CAMERA OBSCURA, is the Name of an Optic Machine; wherein (the Light only coming through a double Convex-Glass,) Objects exposed to broad Day-light, and opposite to the Glass, are represented inverted upon any white Matter, placed within the Machine in the Focus of the Glass. The first who observed this Phænomena was *Baptista Porta*, lib. 4. c. 2. *Magia Naturalis.*

The Representations of Objects in this Machine are wonderfully pleasant, not only because they appear in the just Proportions, and are endued with all the natural Colours of their Objects, but likewise shew their various Motions, which no Art can imitate; and a skilful Painter, by means of one of these Machines, may observe many things from the Contemplation of the appearing of Objects therein, that will be an help to the Perfection of the Art of Painting; and even a Bungler may accurately enough delineate Objects by means of it.

Mr. *s'Gravesande*, at the end of his Perspective, has given the Description and Use of two Machines of this kind, being the best that have as yet been made, especially the former.

CANCER, one of the twelve Signs of the Zodiac, drawn on the Globe in the Figure of a Crab, and thus mark'd ♋, and that Circle that is parallel to the Equinoctial, and passes through the Beginning of this Sign, is called the *Tropic of Cancer*, or the *Northern Tropic*; to which Circle when the Sun comes, it makes the Summer Solstice, and is turning his Course back again towards the Equinoctial.

CANIS *Major* and *Minor*, the greater and lesser Dog, are two Constellations of Stars drawn upon the Globe in figure of this Animal, and the greater of them has in his Mouth that vast Star called

CANICULUS, or the *Dog-Star*, which rising and setting with the Sun from about the 24th of *July* to the 28th of *August*, gives occasion to that time, which is usually very hot and dry, to be called the *Canicular*, or *Dog-Days*.

CANNON, a Piece of Ordnance. See *Ordnance*.

CANNON-ROYAL, is a Piece of Ordnance, eight Inches in Diameter

ter in the Bore, twelve Foot long, weighs eight thouſand Pounds; its Charge is thirty-two Pounds of Powder; its Ball is forty-eight Pounds Weight, and ſeven Inches and a half in Diameter, and ſhoots point-blank one hundred and eighty-five paces.

CANON, in Arithmetic, is a Rule to ſolve all things of the ſame nature with the preſent Enquiry. Thus every laſt Step of an Equation in Algebra, is ſuch a Canon, and if turn'd into Words, is a Rule to ſolve all Queſtions of the ſame nature with that propoſed. The Tables of Logarithms, artificial Sines, and Tangents, are called likewiſe by the Name of *Canon*.

CANON, in Muſic, is a Line of any length, ſhewing by its Diviſions, how muſical Intervals are diſtinguiſh'd according to the Ratio's or Proportions that the Sounds terminating the Intervals bear the one to another, when conſider'd according to their degree of being acute or grave. As the Diapaſon conſiſts in a double Ratio, the Diapente in a Seſquialteral, the Diateſſaron in a Seſquitertian, and the Tone itſelf, by which the Diapente and the Diateſſaron differ, in a Seſquioctave, &c.

CANTALIVERS, in Architecture, are a kind of Modillions; only thoſe are plain, but theſe are carv'd. They are much the ſame with Cartouzes, and are ſet as Modillions are, under the Corona of the Corniſh of a Building.

CANVAS-BAGS, or *Earth-Bags*, are Bags holding about a Cubic Foot of Earth, and are uſed to raiſe a Parapet in haſte, or to repair one that was beaten down. They are chiefly uſed when the Ground is rocky, and affords no Earth to carry on the Approaches: Then are theſe Bags of Earth very neceſſary, which can be fill'd at another place, and remov'd at pleaſure. Theſe Bags are ſometimes, upon occaſion, fill'd with Powder.

CAP-SQUARES, are broad Pieces of Iron on each ſide of the Carriage of a great Gun, and lock'd over the Trunnions of the Piece with an Iron Pin. Their Uſe is to keep the Piece from flying out of the Carriage when it is ſhot off with its Mouth lying very low, or, as they call it, under Metal.

CAPACITY, is the ſolid Content of any Body; alſo our hollow Meaſures for Wine, Beer, Corn, &c. are called Meaſures of Capacity.

CAPE, or *Promontory*, is any high Land, running out with a Point into the Sea; as *Cape Verde*, *Cape Horn*, the *Cape of Good Hope*, &c.

CAPELLA, a bright fix'd Star in the left Shoulder of *Auriga*, whoſe Longitude, according to *Hevelius* (in his *Prodromus Aſtronom.* for the Year 1700,) is $17^{\circ}. 40'. 46''.$ in ♊, and Northern Latitude $22^{\circ}. 52'. 9''.$

CAPITAL *of a Baſtion*, is a Line drawn from the Angle of a Polygon to the Point of the Baſtion, or from the Point of the Baſtion to the middle of the Gorge. Theſe Capitals are from thirty-five to forty Fathom in length; that is, from the Point of the Baſtion to the Place where the two Demi-Gorges meet.

CAPITAL, or *Chapital*, or *Chapiter*, ſignifies the top of a Pillar; and this is different, according to the different Orders.

CAPITAL-LINE. See *Line*.

CAPONNIERE, is a cover'd Lodgment of about four or five Foot broad, encompaſſed with a little Parapet of about two Foot high, which ſerves to ſupport divers Planks laden with Earth.

This Lodgment is large enough to contain fifteen or twenty Soldiers, and is uſually placed upon the Extremity of the Counterſcarp, having ſometimes ſeveral little Embraſures made therein, uſually called Mad-

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Capital-Line. See *Line*.

Caponniere, is a cover'd Lodgment of about four or five Foot broad, encompassed with a little Parapet of about two Foot high, which serves to support divers Planks laden with Earth.

This Lodgment is large enough to contain fifteen or twenty Soldiers, and is usually placed upon the Extremity of the Counterscarp, having sometimes several little Embrasures made therein, usually called Mad-

neſſes. They are generally on the Glacis, or in dry Moats.

Capricorn, the *Goat*, one of the Zodiacal Signs, mark'd thus ♑. The Tropic of *Capricorn*, or the Southern Tropic, paſſes through the firſt Degree of this Sign, at twenty-three Degr. thirty Minutes Diſtance from the Equinoctial.

Caract, is the $\frac{1}{24}$ Part of any Quantity, or Weight; being a Word uſed by *Minters* and *Goldſmiths*, who divide it into four parts, which they call Grains of a Caract; and one of theſe they ſubdivide into Halves and Quarters.

Carat. A Carat of Gold is properly the Weight of twenty-four Grains, or one Scruple; ſo that 24 Carats make an Ounce.

And if an Ounce of Gold be ſo pure, that in its Purification with Antimony, or otherwiſe, it loſes nothing at all, it is then ſaid to be Gold of twenty-four Carats: If it loſes one Carat, it is then Gold of twenty-three Carats: If it loſes two Carats, it is called Gold of twenty-two Carats, *&c.*

A Carat of Diamonds, Pearls, or precious Stones, is the Weight of four Grains only.

Carcass, is an Iron Caſe, or hollow Capacity, about the Bigneſs of a Bomb; ſometimes made all of Iron, except two or three Holes, through which the Fire is to blaze; and ſometimes made only of Iron Bars, or Hoops, and then cover'd over with pitch'd Cloth, Hemp, *&c.* and fill'd with ſeveral kinds of Materials for firing of Houſes. They are thrown out of Mortar-pieces into beſieg'd Places, *&c.*

Card. See *Chard.*

Cardinal-Winds, are the South, Weſt, North, and Eaſt Points of the Compaſs: Alſo the Equinoctial and Solſtitial Points of the Ecliptic, are called the *Four Cardinal-Points.*

Cardinal-Signs, are the Signs of the Zodiac, *Aries, Libra, Cancer,* and *Capricorn.*

Carriage *of a great Gun*, is the Frame of Timber, on which a piece of Ordnance is laid, fix'd and mounted. The common Proportion is one and a half of the Length of the Gun for the Carriage; the Wheels half of the Length of the Piece in height, and four times the Diameter of the Bore of the Gun, gives the depth of the Planks at the fore-end, in the middle three and a half.

Cartouche, the ſame as *Cartridge.*

Cartridges, or *Cartriages*, are Caſes of Paper, or Parchment, fitted exactly to the Bore of a Piece of Ordnance, or Muſquet, and containing its due Charge of Powder.

Cartouzes, are Ornaments of carv'd Work, of no determinate Figure, whoſe Uſe is to receive a Motto, or Inſcription.

Caryatides, from the *Greek Caryatides*, a People of *Caria.* Theſe in Architecture ſignify certain Figures of captive Women, with their Arms cut off, cloathed after the manner of that Nation, down to their Feet, and ſerve inſtead of Columns to ſupport the Entablements.

Cascabell, is the hindermoſt round Knob, or the utmoſt part of the Breech of a piece of Ordnance.

Cascade, an *Italian* Word, that ſignifies a Fall of Waters, either natural or artificial.

Cascan, in Fortification, is a certain Hole, or hollow Place in figure of a Well, from whence a Gallery, dug in like manner under ground, is convey'd to give Air to the Enemies Mine. Some of theſe are more hollow than others, and they are uſually made in the Retrenchment of the Platform near the Wall.

Casemate, in Fortification. This sometimes signifies a Well, with its several subterraneous Branches, or Passages, dug in the Passage of the Bastion, till the Miner is heard at work, and Air given to the Mine. It sometimes signifies

A Vault of Stone-Work in that part of the Flank of a Bastion being next to the Curtain, on purpose to fire upon the Enemy, and to defend the Face of the opposite Bastion of the Moat.

It sometimes consists of three Platforms, one above another; the Terre-plan of the Bastion being the highest. Behind the Parapet that fronts along the Line of the Flank, there are Guns placed loaded with Cartridges of small Shot, to scour along the Ditch; and these are cover'd from the Enemies Batteries by Earth-Works, faced or lined with Walls, and are called Orillons, or Epaulments.

Casern, in Fortification, is a little Room, Lodgment, or a Building, erected between the Houses of fortified Towns and the Rampart, serving as Apartments, or Lodgings, for the Soldiers of the Garrison, to ease the Garrison. There are commonly two Beds in each Casern for six Soldiers to lie in, three and three in a bed; but the third part of them being always upon the Guard, there are but four left in the Casern, two in a bed.

Case-Shot, are Musket-Balls, Stones, old Iron, &c. put into Cases, and so shot out of great Guns; and they are principally used at Sea, to clear the Enemies Decks, when they are full of Men.

Cassiopea, the Name of one of the Constellations of the fix'd Stars in the Northern Hemisphere, consisting of twenty-five Stars, and is placed opposite to the great Bear, on the other side the Pole-star.

Cast *a Point of Traverse*, in Navigation, signifies to prick down on the Chart the Point of the Compass any Land bears from you, or to find on what Point the Ship bears at any Instant, or what way the Ship has made.

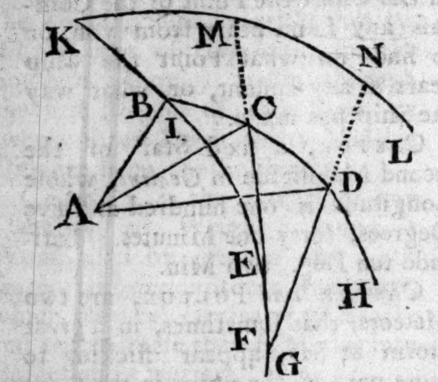
Castor, a fix'd Star of the second Magnitude in *Gemini*, whose Longitude is one hundred and five Degrees, forty-one Minutes. Latitude ten Deg. two Min.

Castor *and* **Pollux**, are two Meteors, that sometimes, in a great Storm at Sea, appear sticking to some part of the Ship, in the shape of fiery Balls; and when but one of them is seen, it is called *Helena*; and both of them are by some called *Tyndaridæ*.

A Constellation of the fix'd Stars being the same with *Gemini*, one of the twelve Signs of the Zodiack, is called by the Name of *Castor and Pollux*.

Catacaustics, or *Caustics by Reflection*. These Curves are generated after the following manner: If there be an infinite Number of Rays, as AB, AC, AD, &c. proceeding from the radiating Point A, and reflected at any given Curve, BDH, so that the Angles of Incidence be still equal to those of Reflection, then the Curve BEG, to which the reflected Rays BI, CE, DF, &c. are Tangents continually; as in the Points I, E, F, &c. is called the *Caustic by Reflection*. Or it is the same thing, if we say, that a Catacaustic Curve is that form'd by joining the Points of Concurrence of the several reflected Rays. And if the reflected Ray IB be produced to K, so that $AB = BK$, and the Curve KL be the Evolute of the Caustic BEG, beginning at the Point K, then the Portion of the Caustic $BE = AC - AB + CE - BI$ continually. Or if any two incident

Rays, as A B, A C, be taken, that Portion of the Caustic that is



evolved, while the Ray A B approaches to a Co-incidence with A C, is equal to the Difference of those incident Rays + the Difference of the reflected Rays.

When the given Curve B D H is a Geometrical one, the Caustic will be so too, and the Caustic will always be rectifiable.

The Caustic of the Circle is a Cycloid, form'd by the Revolution of a Circle along a Circle.

The Caustic of the vulgar Semi-Cycloid, when the Rays are parallel to the Axis thereof, is also a vulgar Cycloid, described by the Revolution of a Circle upon the same Base.

The Caustic of the Logarithmic Spiral is the same Curve.

Catacaustics, or *Cataphonics*, is the Science of reflected Sounds; or that which treats of the Doctrine and Proportions of Echoes.

Catadioptrical Telescope, or *Reflecting Telescope*. See *Telescope*.

Catapulta. A warlike Engine of the Ancients, which shot Darts, Lances, and long Spears: and sometimes cast both Darts and Stones. Some of these Instruments were of such Force, as to throw Spears, or rather Beams of eighteen Feet long, with Iron Heads, and Stones of three Talents, or three hundred and sixty Pound weight, to the Distance of about Half a Quarter of a Mile. See their Description by *Vitruvius*, Lib. 10. cap. 15. See also Mr. *Perrault* upon *Vitruvius*, fol. 335. as also *Rivius*, fol. 597.

Cataract, is a Precipice in the Channel of a River, caused by Rocks, or other Obstacles, hindering the Course of its Stream, from whence the Water falls with great Impetuosity; as, the River *Nile* has two; the River *Wologda* in *Muscovy*; the River *Zaire* in the Kingdom of *Congo*, &c.

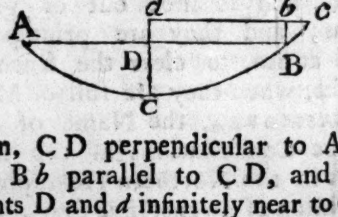
Catches, are those Parts of a Clock that hold by hooking, and catching hold of.

Catenaria, the Name of a Curve-Line, form'd by a Rope, hanging freely from two Points of Suspension, whether the Points be horizontal or not.

The Nature of this Curve was sought after in *Galileo*'s Time; but little was done concerning it, till the Year 1690 Mr. *Bernoulli* proposed it as a Problem to the Mathematicians of *Europe*.

This Catenary is a Curve of the Mechanical kind, and cannot be expressed by a finite algebraic Equation.

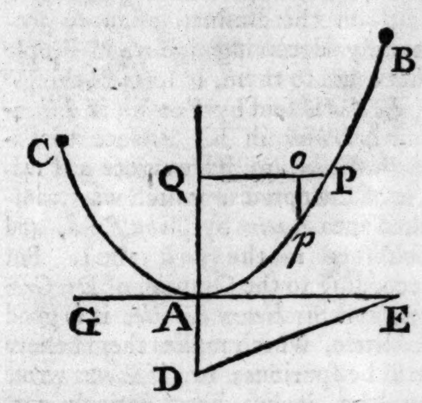
If you suppose a Line heavy and flexible, firmly fixed to the Points A, B, the Extremes thereof, then the Weight thereof will bend it into the Curve A C B, called the *Catenary*, whose fundamental Property (if D B, $d\,c$, be parallel to the Ho-



rizon, C D perpendicular to A B, and B b parallel to C D, and the Points D and d infinitely near to one another, and a be any given Quantity) will be this, *viz.* $b\,c$: Bb ::

a : C B. The Demonſtration of this Property, as alſo of ſeveral others, may be ſeen in what was publiſhed by Dr. *Gregory* in the year 1697, for the Month of *Auguſt*: ſee alſo its Conſtruction and Nature by Mr. *John Bernoulli* in the *Acta Eruditorum*, for the year 1691, p. 277.

But as Mr. *Cotes*, in his *Harmony of Meaſures*, has given a ſhort and neat Account, why may not I lay down the ſame here? Let B A C be a very ſlender Chain, or rather mathematical Line, flexible throughout by any ſmall Force, which can be neither extended or contracted. This



ſuſpended by its Ends B, C, by the Force of its own Weight, equally diffuſed through all its equal Particles, is ſtretch'd into the Curve B P p A C: it is required to find any Points of this Curve. If a Plane be ſuppoſed to paſs thro' its Ends B, C, perpendicular to the Horizon; it is evident, that all the Points of the propoſed Curve are ſituated in this Plane; and ſo, that each will deſcend as low as it can. thro' its loweſt Point A draw A Q perpendicular to the Horizon, and let P o Q drawn from any Point P, be perpendicular to it, and thro' p, being the neareſt Point to P poſſible, let $p\,o$ be drawn parallel to A Q; call A Q, x; P Q, y; and the Arch A P, z; then will the very ſmall Lines P o, P p, be to one another as $\dot{x}$, $\dot{y}$, $\dot{z}$.

Then becauſe the Arch A P is ſuſtain'd *in Equilibrio*, by the Force of its Weight, whoſe Direction is parallel to the Line $o\,p$, by the Force of the contiguous Arch A C drawing according to the Direction of the Tangent at A, parallel to the little Line P o, and by the Force of the contiguous Arch P B, drawing in the Direction of the Line p P: it is evident from Mechanics, that theſe Forces are to one another as $o\,p$, o P, p P, or as $\dot{x}, \dot{y}, \dot{z}$. Therefore if the Weight of the Arch A P be expreſs'd by its Length z, and the given Force drawing the Arch A C, be expounded by a given Length a, it will be $\dot{x} : \dot{y} :: z : a$; and ſo $\dot{x} : \sqrt{\dot{x}\dot{x} + \dot{y}\dot{y}} = \dot{z} :: z : \sqrt{aa + zz}$.

Therefore $\dot{x} = \frac{\dot{z}z}{\sqrt{aa+zz}}$; and ſo $a + x = \sqrt{aa + zz}$: wherefore $z = \sqrt{\overline{a + x}^2 - aa} = \sqrt{2ax + xx}$. Wherefore, if the right Line Q A be continued downwards to D, ſo that A D be $= a$, and in the Tangent A E be taken A E = to the Arch A P, and D E be join'd: this will be equal to D Q. Wherefore if A E the Length of any Arch A P be given, as alſo A Q the Height of the ſaid Arch: there will be given A D $= a$, by joining Q E, and biſſecting the ſame at right Angles: for the Perpendicular will paſs thro' the Point D. And A D being once given; from thence will be given A E, the Length of any Arch A P, whoſe Altitude A Q is given, by deſcribing a Circle from the Centre D with the Diſtance Q A, which cuts A E in E; and theſe are the mutual Relations of the Parameter A D, the Arch A P, and its Altitude A Q. Let us now ſee about its Breadth.

From

From what has been already said, $\dot{y} = \frac{a\dot{x}}{z} = \frac{a\dot{x}}{x^{\frac{1}{2}}\sqrt{2a+x}}$. And the Fluent of this last Expression will be an hyperbolic Space: which Space may be measured by the Logarithms. So that P Q will be the Logarithm of the Ratio between D E + E A and A D, or of A P + A Q to A P — A Q, (which Ratio is equal to the former) when the Length of the Line A D is 0.43429 4481903. So that A D being given or found, as above; if any Points Q be taken in the Axis A Q, so many correspondent Points P of the Curve will be had.

Cathetus. The perpendicular Leg of a right-angled Triangle, is often called by this Name. Also *Cathetus*, in *Catroptrics*, is a Line drawn from the Point of Reflection perpendicular to the Plane of the Glass.

Cathetus, in Architecture, is taken for a Line supposed to cross the Middle of a cylindrical Body directly, as of a Ballister, or Column. In the Ionic Chapiter it is also a Line falling perpendicularly, and passing thro' the Centre or Eye of the Volute.

Cathetus *of Incidence*, is a right Line drawn from a Point of the Object, perpendicular to the reflecting Line.

Cathetus *of Reflection*, or *Cathetus of the Eye*, is a right Line, drawn from the Eye, perpendicular to the reflecting Line.

Catoptrics, is that part of Optics that treats of reflex Vision, and explains the Laws and Properties of Reflexion; chiefly founded upon this Truth, that the Angle of Reflection is always equal to the Angle of Incidence; and from thence deducing the Magnitudes, Shapes, and Situations of the Appearances of Objects, seen by the Reflexion of polish'd Surfaces; and particularly, Plane, Spherical, Conical, and Cylindrical ones.

This is a very diverting and useful Part of Knowledge. The Phænomena arising from the Effects of the Instruments that have been invented in this Art, are surprizing, even to those who know the Reasons of the Phænomena they exhibit: But many of those, who are ignorant thereof, have thought that those wonderful Phænomena were produced by Divination. And those crafty Knaves, called Conjurers, or Cunning Men, have often had recourse to catoptric Instruments, to help on the Business of more profoundly deceiving ignorant People that came to them, to foretell things.

Euclid is said by *Proclus*, in *Lib.* 2. and *Marinus* in his Preface to *Euclid*'s *Data*, to have wrote a Treatise of Catoptrics, which was translated into *Latin* by *John Pena*, and published in the year 1604. But according to the Opinion of Dr. *Gregory* and Sir *Henry Savile*, it is good for little, which makes them believe it to be spurious; or, if it was wrote by him, it has been entirely corrupted by the Length of Time.—— You have it in *Peter Herigon*'s *Course of Mathematics*: as also in Dr. *Gregory*'s Edition of *Euclid*'s Works.— *Alhazen* an *Arabian*, compiled a large Volume of Optics, wherein he treats of Catoptrics, about the year 1100; and after him, *Vitellio* a *Polander* published another, in the year 1270.—*Andrew Tacquet*, in his *Optics*, has very well demonstrated the fundamental Propositions of plane and spherical Speculums.——So also has Dr. *Barrow*, in his *Optical Lectures*.——There is moreover *Zachary Trabe*'s *Catoptrics*, *David Gregory*'s *Elements of Catoptrics*, *Wolfius*'s *Elements of Catoptrics*, and the learned Dr. *Smith*'s *Catoptrics*; with several others that I do not here mention.

CAVALIER, in Fortification, is a Heap of Earth raised in a Fortress, to lodge the Cannon for scouring the Field, or opposing a commanding Work. They are sometimes of a round, and sometimes of a square Figure; and the Top is bordered with a Parapet, to cover the Cannon mounted in it. There must be twelve Foot between Cannon and Cannon; and if they are raised on the Inclosure of any Place, whether in the Middle of the Curtain, or in the Gorge or Bastion, they are generally fifteen or eighteen Foot high above the Terre-Plane of the Rampart.

A *Cavalier* is sometimes called a *Double Bastion*; and the Use thereof is to overlook the Enemy's Batteries, and to scour their Trenches.

CAVAZION, in Architecture, is the Digging or Hollowing away of the Earth from the Foundation of a Building; and this may be one sixth Part of the Height of the whole Building.

CAVETTO, is a round Concave Moulding having a quite contrary Effect to the Quarter-Round. The Workmen call it a *Mouth*, when it is in its natural Situation; and *Throat*, when it is turned upside down.

CAUKING, in Architecture, is Dove-tailing across.

CAULICOLI, in Architecture, are the little carved Scrolls, which are under the *Abacus* in the Corinthian Order.

CAUSTIC CURVES. See *Catacaustics*, and *Diacaustics*.

CAZERN. See *Casern*.

CAZEMATE. See *Casemate*.

CEGINUS, a Fixed Star of the first Magnitude, in the left Shoulder of *Boötes*; whose Longitude is 194 deg. 5 min. Lat. 49 deg. 33 min. and right Ascension 215deg. 39 min.

CELERITY, is the Swiftness of any Body in motion; and is defined to be an Affection of Motion, by which any moveable Body runs thro' a given Space in a given Time.

CELESTIAL GLOBE. See *Globe*.

CENTAUR, a Southern Constellation, consisting of forty Stars.

CENTESM, is the hundredth Part of any Thing.

CENTRAL RULE, is a Rule found out by Mr. *Thomas Baker*, and by him publish'd, in his *Geometrical Key*, in the year 1684; whereby he finds the Centre of a Circle, that is to cut a given Parabola in as many Points as an Equation, to be constructed, has real Roots: And by that means he constructs all Equations, not exceeding Biquadratics, without any previous Reduction or Alteration whatsoever.

CENTRE *of a Circle*, is a Point within the same, from whence all right Lines, that are drawn to the Circumference of the Circle, are equal to each other.

CENTRE *of a Dial*, is that Point where the Axis of the World intersects the Plane of the Dial: And so, in those Dials that have Centres, it is that Point wherein all the Hour-Lines meet. All Dials have Centres, but such as are parallel to the Axis of the World.

CENTRE *of an Ellipsis*, is that Point thereof, wherein the Diameters intersect each other; or it is that Point bissecting any Diameter.

The same may be said of the Centre of an Hyperbola.

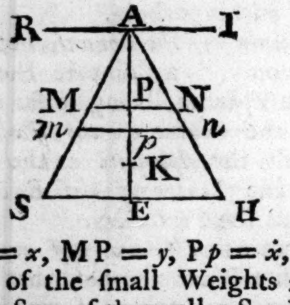
CENTRE *of the Equant*, in the old Astronomy, is a Point in the Line of the *Aphelion*, being so far distant from the *Centre of the Excentric*, towards the *Aphelion*, as the Sun is from the *Centre of the Excentric*, towards the *Perihelion*.

CENTRE *of Gravity of any Body*, is such a Point thereof, that if the Body be supported on it, or suspended from it, the Body will rest in any given Situation.

Centre (Common) *of Gravity of two Bodies*, is a Point in a Right Line, joining their Centres, so posited, that their Distances from it are reciprocally proportional to the Weights of the Bodies. And if there be another Body in the same Right Line, so placed, that its Distance from some Point in it be reciprocally, as the Weight of both the former Bodies taken together, that Point shall be the common Centre of Gravity of all three of the Bodies. Understand the same of the common Centre of Gravity of four, or more Bodies.

1. The common Centre of Gravity of two or more Bodies, does not change its State of Motion, or Rest, by the Actions of Bodies among themselves. And so the common Centre of Gravity of all Bodies, mutually acting upon each other, (all external Actions and Impediments being excluded,) will either rest, or move uniformly forwards in a straight Line.

2. If the Elements, or infinitely small Parts, as m M N n of any Figure S A H, be conceived as so many Weights hung to the Axis A E, the Point of Suspension being in the Vertex A, the Centre of Gravity K, in that Axis, will be determin'd by dividing the Sum of the Moments of all those small Weights by the Sum of them all, that is,



if AP $= x$, MP $= y$, P$p = \dot{x}$, then is one of the small Weights $2y\dot{x}$, and the Sum of them all $2\,S\,y\,\dot{x}$, the Moment of one of the small Weights is $2yx\dot{x}$, and the Sum of them all is $2\,S\,y\,x\,\dot{x}$; whence the Distance of the Centre of Gravity from the Vertex is $\frac{S\,y\,x\,\dot{x}}{S\,y\,\dot{x}}$; and so when you have the flowing Quantities of these Fluxions $yx\dot{x}$ and $y\dot{x}$, the Centre of Gravity will be determined.

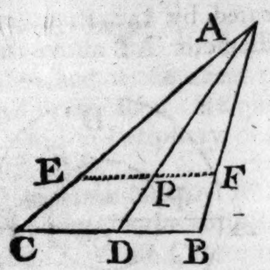
3. Every Figure, whether superficial or solid, which is generated by the Motion of a Line or Figure, is equal to the Rectangle under the generating Magnitude, and the Way of its Centre of Gravity, or the Line which the Centre of Gravity describes.

The Demonstration of this most excellent Theorem may be thus: Let us conceive the Weight of the whole generating Magnitude to be collected into the Centre of Gravity; then the whole Weight, produced by that Motion, will be equal to the Product of the Weight moved into the way of the Centre of Gravity; but since Lines and Figures may be considered as homogeneous Weights, their Weights are to one another, as their Bulks: and so the Weight moved is the generating Magnitude, and the Weight produced, the generated Magnitude. Wherefore the Figure generated, is equal to the Product of the generating Magnitude, drawn into the way of its Centre of Gravity.

4. In homogeneous Magnitudes, which can be divided lengthwise into similar and equal Parts, the Centre of Gravity is the same as the Centre of Magnitude. And so the Centre of Gravity of any physical Right Line is in the Middle thereof; as likewise is that of a Parallelogram, Cylinder, &c. Moreover the Centre of Gravity of any equilateral Triangle, regular Polygon, Circle, or Ellipsis, is the same as the Centre of Magnitude; as is that of a regular Polyhedron, Sphere, and Spheroid, &c.

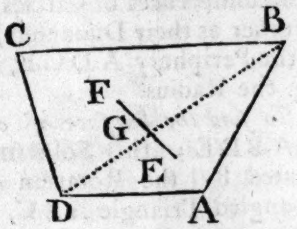
5.

5. In any Triangle A B C, if the Base B C be bissected by the Right



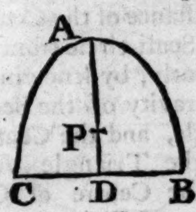
Line A D, the Centre of Gravity P of that Triangle will be in that Line, at a Distance from the Vertex A, equal to $\frac{2}{3}$ of the bissecting Line A D. And if the Right Line E F be drawn thro' P, parallel to the Base C B; dividing the Triangle into two Parts C E F B and E A F, the Part E A F next to the Vertex will be less than the Part C E F B next to the Base.

6. If a Trapezium A B C D be divided into two Triangles D A B,



D C B, by a Diagonal D B; and if E be the Centre of Gravity of the Triangle D B A, and F that of the Triangle D C B: and the Line E F joining the said Centres, be divided in G, in such manner, that the whole Line E F be to the Distance F G, as the Trapezium is to the Triangle A D B; or the whole Line E F to the Line E G, as the Trapezium is to the Triangle D C B, the Point G will be the Centre of Gravity of the said Trapezium.

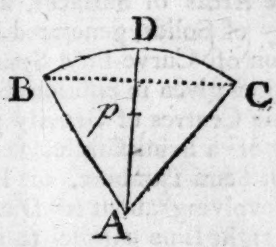
7. If CAB be any Parabola, whose Nature is express'd by the Equation $1 \times x = y^m$, and A D ($= x$) be a Diameter, and C B ($= y$) a double Ordinate, then will $\frac{m+1}{2m+1} \times$ A D



be = A P, the Distance of the Centre of Gravity P from the Vertex A of the Figure. So that when $m = 2$, as in the *Apollonian* Parabola, A P will be $= \frac{3}{5}$ A D; if m be $= 3$, as in the cubical Parabola, we shall have A P $= \frac{4}{7}$ A D; if $m = 4$, as in the biquadratical Parabola, we shall have A P $= \frac{5}{9}$ A D; and so on. But if m be $= \frac{1}{2}$, in which Case the Axis A D of the Parabola becomes a Tangent to the Vertex, we shall have $\frac{3}{4}$ A D for the Distance of the Centre of Gravity of a double external parabolical Space from the Vertex; if m be $= \frac{1}{3}$, A P will be $= \frac{4}{5}$; if m be $= \frac{1}{4}$, A P will be $= \frac{5}{6}$ A D; and so on.

8. The Distance of the Centre of Gravity of an Arch of a Circle, from the Centre of the Circle, is to the Radius, as the Chord of that Arch is to the Arch itself; and in the Semi-circumference, as the Diameter is to the Semi-circumference.

9. If A B C be a Sector of a Circle, and the Radius A D bissects the



Arch B C, then the Distance A P of the Centre of Gravity P of that Sector, will be to $\frac{2}{3}$ of the Radius A D, as the Chord of the Arch B C to

to the Arch BC itself: so that in a Semicircle, as half the Circumference is to its Chord, so is $\frac{2}{3}$ of the Radius to the Distance of the Centre of Gravity of a Semi-circle from its Centre. Consequently, by knowing the Centre of Gravity of the Sector ABC of a Circle, and the Centre of Gravity of the Triangle ABC, we can find the Centre of Gravity of the Segment BDC of a Circle.

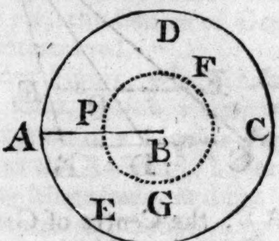
10. The Centre of Gravity of a Pyramid, or Cone, is distant from the Vertex $\frac{3}{4}$ parts of the Axis.

11. The Centre of Gravity of a Parabolic Conoid is distant from the Vertex $\frac{2}{3}$ Parts of the Axis.

12. In a Segment of a Sphere, it is as three times the Radius lessen'd by the Altitude, is twice the Radius lessen'd by $\frac{3}{4}$ of the Altitude of the Segment; so is the Altitude of the Segment to the Distance of the Centre of Gravity from the Vertex. and the Segments of Spheres and Spheroids having a common Altitude, have the same Centre of Gravity.

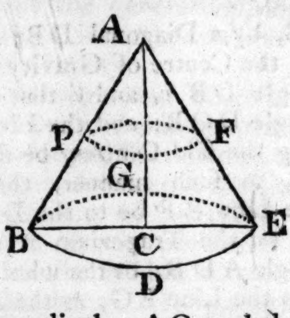
13. In an Hyperbolic Conoid, as six times the transverse Axis added to four times the Altitude of the Conoid, is to four times the transverse Axis added to three times the Altitude; so is the Altitude to the Distance of the Centre of Gravity from the Vertex.

The Theorem above-mentioned at *n.* 3. is of excellent use in finding out the Areas of Surfaces, and the Solidity of Solids, generated by the Rotation of Curve-lin'd Spaces, about Lines given in position, by having their Centres of Gravity given; as that of a Semi-Circle, Semi-Ellipsis or Semi-Parabola, or Hyperbola, revolving about its Diameter, or any right Line parallel to it, the Segment of a Circle, Ellipsis, Parabola, or Hyperbola about its Base, or any right Line parallel to it, or a whole Ellipsis about any right Line parallel to its Axis, *&c.* Take a few Examples: 1. *To find the Area of a Circle* ADCE. This may be generated by the Rotation of the Semidiameter AB above the Centre



B. But since the Centre P of Gravity of AB is in the middle thereof, and this describes the Periphery PFG of a Circle, Concentric to ADCE, whilst AB is describing ADCE; therefore the Area of the Circle ADCE, will be equal to the Periphery PFG, (being the way of the Centre of Gravity P) drawn into $\frac{1}{2}$ AB, that is, (since the Circumferences of Circles are to each other as their Diameters) equal to $\frac{1}{2}$ the Periphery ADCE, drawn into $\frac{1}{2}$ the Radius.

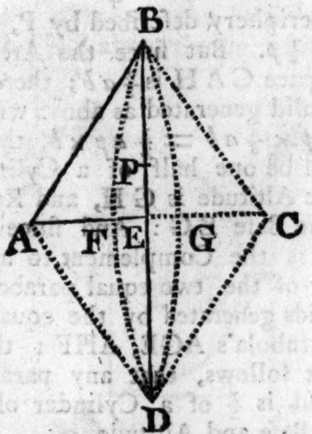
2. *To find the Surface of a right Cone* ABDE; this Solid may be generated by the Rotation of the right-angled Triangle ABC, about



its Perpendicular AC, and the Surface thereof generated by the Rotation of the Hypotheneuse AB. Where since P, the middle of AB, is the Centre of Gravity of AB; the Rectangle under AB, and the Circumference of a Circle PGF, being

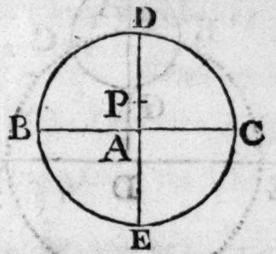
being the way of the Centre of Gravity, will be equal to the Surface of the Cone; that is, since the Circumference P G F, is $\frac{1}{2}$ of the Circumference B D E; the Area of the Surface of the Cone will be one half the slant Height A B, drawn into the Periphery B D E of the Base.

3. *To find the Solidity of a Cone* A B F D; suppose the Isosceles Triangle A B C, whose Centre of Gravity is P, to revolve about its side A C; this will describe a double



Cone A B C D, the half of which will be the Cone A B F D, whose Base is the Circle F B G D, and Altitude the Line A E, being the half of the side A C of the Isosceles Triangle A B C. Therefore the Solidity of this Cone will be equal to the Area of $\frac{1}{2}$ the Triangle A B E, drawn into the Circumference of a Circle, whose Radius is E P, this being the way of the Centre of Gravity P; but since E P is $= \frac{1}{3}$ E B, the Periphery describ'd by P will be $\frac{1}{3}$ of that describ'd by B. Consequently the Solidity of the said Cone will be $= \frac{1}{3}$ of the Periphery of the Base drawn into $AE \times \frac{1}{2} EB$ $=$ Periphery of the Base $\times \frac{1}{2} EB \times \frac{1}{3} AE =$ Base $\times \frac{1}{3} AE$.

4. *To find the Solidity of a Sphere.* A Sphere may be generated by the Rotation of a Semicircle B D C, about the Diameter B C. Let the

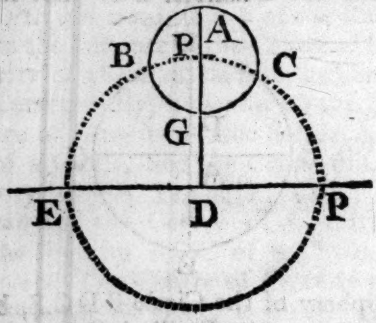


Periphery of the Circle B D C E, be be called p; its Radii A D, r; and then (by 9. of this) the Distance A P of the Centre of Gravity P from A, will be $= \frac{8rr}{3p}$. and so the way of the Centre of Gravity P, or Circumference of the Circle described by A P, will be $\frac{8r}{3}$. And since the Semicircle BDC is $= \frac{pr}{4}$; the Solidity of the Sphere will be $\frac{8r}{3} \times \frac{pr}{4} = \frac{8}{6} r \times \frac{pr}{2} = \frac{4}{3} r \times \frac{pr}{2} = \frac{2}{3} \times 2r \times \frac{pr}{2} = \frac{2}{3}$ DE $\times$ Circle B D C E.

5. *To find the Surface of the said Sphere*; the Distance AP of the Centre of Gravity of the Semicircumference B D C, describing the Surface of the Sphere, in this case will be (by 8. of this) $= \frac{4rr}{p}$. and the way of the said Centre of Gravity will be $= 4r$. Therefore $4r \times \frac{p}{2} = 4 \times \frac{rp}{2}$ $= 4 \times$ Area of the Circle B D C E, will be the Surface of the Sphere.

6. *If the Plane of a Circle* A B G C, *whose Centre is* P, *revolves about the right Line* E F, *at the Distance* D P *from its Centre, thereby generating a Cylindrical Ring: The Solidity of that Ring will be*

be equal to a Cylinder, whose Base is the Circle ABGC, *and Altitude*

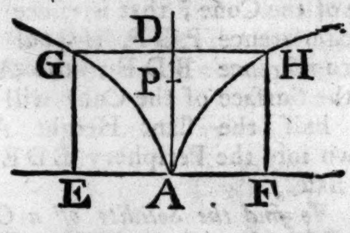


the Circle whose Radius is the right Line DP. This is evident, because the Centre of Gravity of the Circle, is the same as the Centre of the Circle, and the way of the Centre of Gravity is the Periphery, whose Radius is DP.

7. And *the Surface of that Solid is equal to the Surface of that Cylinder.*

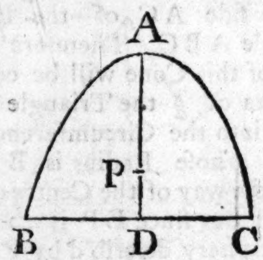
8. If the said Ring be divided into two parts by a Cylindrical Surface passing thro' the Circumference of the Circle, described by the Centre P of the generating Circle ABGC, the outermost part of that Ring will be to the innermost, as $\frac{3}{8}$ DP $\times p + rr$ is to $\frac{3}{8}$ DP $\times p - rr$, and the Surface of the one will be to that of the other, as $\frac{1}{4}$ DP $\times p + rr$ is to $\frac{1}{4}$ DP $\times p - rr$. Both these Propositions evidently follow upon the Supposition that the Distance of the Centre of Gravity of a Semicircle from the Centre of the Circle is $\frac{8rr}{3p}$, and that of the Semicircle $\frac{4rr}{p}$.

9. *If* AG, AH, *be two equal Parabola's touching one another in their principal Vertex* A, *and the Trilineal Space* GAH *revolves about the common Axis* EAF *of the Parabola's, and it be required to find the Solidity of the Solid generated by such a Motion.* Let us call EG or FH, a; EA or AF, b. and the Periphery of the Circle, whose



Radius is E,G, or AD, p. and suppose P to be the Centre of Gravity of the said Trilineal Space AGH, then will AP be $= \frac{3}{4}a$; and so the Periphery described by P, will be $= \frac{3}{4}p$. But since the Area of the Space GAH is $\frac{2}{3}ab$; therefore the Solid generated as above will be $= \frac{3}{4}p \times \frac{2}{3}ab = \frac{1}{2}ap \times b$, that is it will be one half of a Cylinder, whose Altitude is GH, and Radius of the Base EG: And since this Solid is the Complement to a Cylinder of the two equal parabolical Conoids generated by the equal Semi-parabola's AGE, AHF; therefore it follows, that any parabolic Conoid is $\frac{1}{2}$ of a Cylinder of the same Base and Altitude.

10. *If the Parabola* BAC *revolves about its Base* BC, *or double Ordinate* BC: *to find the Solidity of*

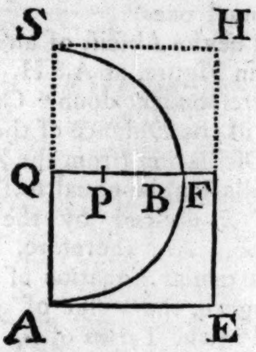


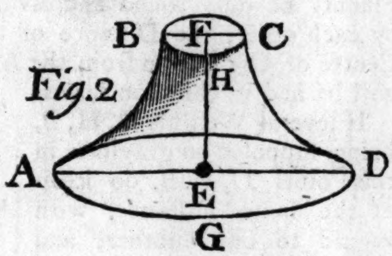
the Solid generated thereby. Let us call the Axis AD, a; the Base CB, b, and the Circumference (whose Radius is a,) p, then will PD be $= \frac{2}{5}a$; and the Circumference described by P, will be $\frac{2}{5}p$. Therefore $\frac{2}{3}ab \times \frac{2}{5}p = \frac{4}{15}abp$ also will be equal to

to the Solid generated as above, which will be to its circumscribing Cylinder as $\frac{4}{15}$ to $\frac{1}{2}$, or as 8 to 15.

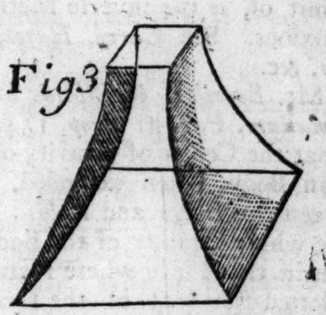
11. *To find the Solid generated by the Rotation of the Quadrilineal Space* ABFE (*contain'd under the Quadrantal Circular Arch* AB, *the Tangent* AE, *the Perpendicular* EF, *equal to the Radius* AQ, *and the Continuation* BF *of the Radius* QB) *about the right Line* FE.

It is plain from the Generation, that the Solid thus generated is one half of the Solid produced from the Revolution of the whole Space ABSHE about the right Line EH.





And that this last Solid is the Complement of a Cylinder (whose Radius of the Base is AE, and Altitude EF) to the Solid produced by the Rotation of the Quadrant AQB about the Line EF. Let QF, be called a; EF, r; and the Arch of the Circle whose Radius is AQ, p. Then since QP $= \frac{8rr}{3p}$, PF will be $= a - \frac{8rr}{3p}$. and the Periphery described by P, will be $\frac{ap}{r} - \frac{8r}{3}$. Wherefore since the Area of the Quadrant AQB is $= \frac{rp}{8}$, the Area of the Solid generated as above, will be $= \frac{ap}{r} - \frac{8r}{3} \times \frac{pr}{8} = \frac{app}{8} - \frac{rrp}{3}$. And so because $\frac{aap}{2}$ is the Solidity of the Cylinder aforesaid; $\frac{aap}{2} - \frac{app}{8} + \frac{rrp}{3}$



will be the Solidity of the Solid required. (See the Solid at Fig. 2.) And as $p : 4r :: \frac{aap}{2} - \frac{app}{8} + \frac{rrp}{3} : 2aar - \frac{1}{2}arp + \frac{4}{3}r^3 =$ Square solid of Fig. 3. that may be inscribed in the solid of Fig. 2. Much after the same manner the Surfaces of these Solids may be found, which I leave to be done by those who delight in these things.

Thus I have given a few Examples of the Excellence of our Theorem, in expeditiously and easily finding the Areas of Surfaces, and Solidities of Solids, by means of the Centre of Gravity. It is mention'd by

by *Pappus* at the latter End of his Preface to his ſeventh Book of Mathematical Collections; but Father *Guldin* the Jeſuit, in his ſecond and third Book of the Centre of Gravity, has more expreſly demonſtrated it by an Induction of ſeveral Examples.

The aforeſaid Father *Guldin*, in his *Centrobarica*, has ſhewn how to find the Centres of Gravity of Figures; and ſo has Dr. *Wallis*, in his Mechanics: But their manner of Performance is both tedious, troubleſome, and imperfect. *Caſatus* too, in his Mechanics, has ſhewn how to find them mechanically, or by Trials. But the moſt ready, elegant, and general Help, that the Nature of the Buſineſs ſeems to admit of, is the inverſe Method of Fluxions. See *Carré*, *Hayes*, *Wolfius*, &c.

Mr. *Borellus*, *in Lib. de Motu Animalium*, *Part* 1. *Prop.* 134. ſays, That the Centre of Gravity of a human Body, when extended, is between the *Nates* and *Pubis*; and ſo the whole Gravity of the Body centres in that Place where Nature has allotted the Seat of the Genitals; which, no doubt, was for facilitating the Buſineſs of Coition.

Centre *of an Hyperbola*, is that Point wherein the Diameters meet; or it is that Point biſſecting any Diameter, and is without the Figure, and common to the oppoſite Sections.

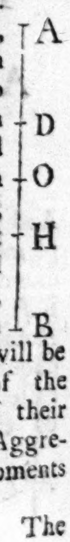
Centre *of Magnitude of any Body*, is that Point which is equally remote from its extreme Parts. In Homogeneal Bodies, that can be cut into like and equal Parts, according to their Length, the Centre of Gravity is the ſame as the Centre of Magnitude.

Such an Homogeneal Body is, for Example, a Leaden Cylinder, that can be cut lengthwiſe into like Parts; for if the Length thereof be conceived to be divided into three or more equal Parts, it will be cut into equal and like Cylinders.

Centre *of Motion of any Body*, is the Point about which any Body moves, when faſten'd any ways to it, or made to revolve round it.

Centre *of Oſcillation*, is a Point, wherein, if all the Gravity of a compound Pendulum be collected, every Oſcillation will ſtill be performed in the ſame time as before. Or it is that Point of a Compound Pendulum, whoſe Diſtance from the Point of Suſpenſion is equal to the Length of a ſimple Pendulum, whoſe Oſcillations are performed in the ſame time as the Oſcillation of the Compound ones.

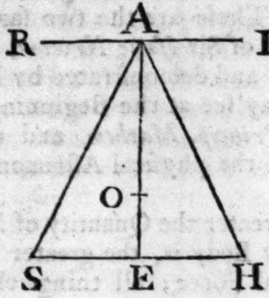
If x be the Abſciſs of an oſcillating plain Figure, as A S H, and $2y$ the correſpondent double Ordinate: then will the Diſtance of the Centre O of Oſcillation (from the Axis R I of Oſcillation) be equal to the fluent of $yx^2\dot{x}$ divided by the Fluent of $yx\dot{x}$. And therefore, if from the particular Equation of any given Figure, the Value of y be expreſſed in the Terms of x, and the Fluents be duly found and divided by each other, the Diſtance of the Centre of Oſcillation from the Axis will be had in common terms.



If ſeveral Weights D, H, B, being ſuppoſed to gravitate in the Points D, H, B, do keep at the ſame Diſtance, with regard to one another, and from the Point of Suſpenſion A, on the inflexible Rod A B, and, oſcillating about the Point A, do make a Compound Pendulum: the Diſtance of O, the Centre of Oſcillation from the Point of Suſpenſion A, will be had, by drawing each of the Weights into the Squares of their Diſtances, and dividing the Aggregate by the Sum of the Moments of the ſame Weights.

The

The Centre (O) of Oscillation of a straight Line AB will be distant from A, the Point of Suspension $\frac{2}{3}$ of the whole Line. The Centre (O) of Oscillation of the Equicrural Triangle ASH, oscillating about the Axis RI, parallel to the Base SH will be distant from A, the Point of Suspension, $\frac{3}{4}$ of AE.



And if SAH was the common Parabola, A being the Vertex, and AE the Axis, then the Distance AO $= \frac{5}{7}$ AE.

Mr. *Huygens*, in his *Horologium Oscillatorium*, has first shewn how to find the Centre of Oscillation. He tells us at the Beginning of his Discourse on this Subject, that *Mersennus* first proposed the Problem to him, when he (*Huygens*) was very young, even a Youth, requiring him to solve the same in Sectors of Circles suspended from their Angles, and the Middles of their Bases; as also when they oscillate side-ways: In the Segment of Circles and Triangles, hanging from their Vertex, and the Middles of their Bases. But, says *Huygens*, I at first, not having found out any thing that would open a Passage into this Business, was repulsed at first setting out, and stopt from a further Prosecution of the thing; till at length being incited thereto, by the Consideration of attempering the Motion of the Pendulums of my Clock, I conquered all Difficulties, going far beyond *Descartes*, *Fabry*, and others, who had done the thing in a few of the most easy Cases only, without any sufficient Demonstration; and not solved *Mersennus*'s Problems only, but found out many others much more difficult, shewing a way of finding this Centre in Lines, Superficies, and Solids.—In the *Acta Eruditorum* for *Leipsick*, An. 1691. pag. 317. ad An. 1714. pag. 257. you have this Doctrine handled by the two *Bernoulli*'s; you have also the same by Mr. *Herman*, in his Treatise *de Motu Corporum Solidorum & Fluidorum*. The same is to be found in Treatises of the Inverse Method of Fluxions: See *Hayes*, *Carré*, *Wolfius*, &c.

Centre *of Percussion*, is that Point of a Body in Motion, wherein all the Forces of that Body are united into one; or it is that Point wherein the Stroke of the Body will be greatest; and is much the same, with respect to the Forces, as the Centre of Gravity to the Weights.

The Centre of Percussion is the same as the Centre of Oscillation, if the striking Body revolves about a fixed Point. Whence a Stick of a Cylindrical Figure, supposing the Centre of Motion at the Hand, will strike the greatest Blow at a distance, about $\frac{2}{3}$ of its Length from the Hand.

The Centre of Percussion is the same as the Centre of Gravity, if all the Parts of the striking Body are carried by a parallel Motion, or move with the same Velocity.

Centre *of a Regular Polygon*, or *Regular* Body, is the same as that of the inscrib'd Circle or Sphere.

Centre *of a Sphere*, is a Point in the middle thereof, from whence all Right Lines, drawn to the Superficies, are equal to one another.

Centrifugal Force, is that Force by which all Bodies that move round any other Body in a Curve,

do endeavour to fly off in every Point of the Curve.

CENTRIPETAL FORCE, is that by which a Body is every where impelled, or any how tends towards ſome Point, as a Centre. Among which may be reckon'd Gravity, whereby Bodies tend towards the Centre of the Earth; the magnetical Attraction whereby it draws Iron; and that Force, whatever it be, whereby the Planets are continually drawn back from right-lin'd Motions, and made to move in Curves.

The Centripetal and Centrifugal Force of the ſame revolving Body in the ſame Point of the Curve that it deſcribes, are always equal and contrary.

If a Body laid upon a Plane, does at the ſame time, and about the ſame Centre revolve with that Plane, and ſo deſcribes a Circle: and if the centripetal Force, by which the Body is drawn or impelled every moment towards that Centre, ſhould ceaſe to act, and the Plane ſhould continue to move with the ſame Velocity; the Body will begin to recede from the Centre, with reſpect to the Plane, in a Line which paſſes thro' the Plane. The truth of which will eaſily appear, by faſtening a Ball to a Packthread, one End of which is fixed to the Centre of a round Table, moving about that Centre, and laying the Ball upon the Plane of the Table, ſo as to roll round together with the Plane of the Table at the ſame time.

When a Body moves about a Centre, if as it moves it comes nearer to the Centre, its Motion is accelerated; but on the contrary, retarded, if it recedes from the Centre.

A Body which is kept moving in a curve Line, by a Force tending towards a fixed Centre, deſcribes Areas (contained under Portions of that Curve, and right Lines drawn from the Body to that Centre) proportional to the time. And contrarywiſe,

That Body which is moved in any Curve in a Plane, and by a Radius drawn to ſome Point at reſt, or moving uniformly in a right Line, deſcribes Areas about that Point proportional to the time, is urged by a centripetal Force tending to that Point.——Theſe are the two famous Theorems of Sir *Iſaac Newton*, firſt found out and demonſtrated by him, as you may ſee at the Beginning of *Lib.* 1. *Princip. Mathem.* and upon which all the phyſical Aſtronomy is founded.

The greater the Quantity of Matter in any Body is, the greater is its centripetal Force; all things elſe alike.

If a Solid with a Fluid be included in a determinate Space; if it be lighter than the Fluid, it will come to the Centre; if heavier, it will recede from that Centre: becauſe the heavier Body has the greater centrifugal Force.

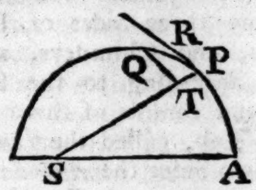
The centrifugal Forces of revolving Bodies, are in a Ratio compounded of their Quantities of Matter; Diſtances from the Centre; and the inverſe duplicate Ratio of their periodical Times.

If a Body moves in an Ellipſis; the Law of the centripetal Force, tending to the Centre of the Ellipſis, will be directly as the Diſtance from the Centre: but if to the Focus, reciprocally as the Square of the Diſtance. The ſame holds good in the Hyperbola and Parabola, when the centripetal Force tends to their Foci.

If ſeveral Bodies revolve about a common Centre, and the centripetal Force be in the reciprocal duplicate Ratio of the Places from the Centre, the principal *Latus Rectums* of the Orbits are in the duplicate Ratio of the Area's, which the Bodies, by Radii

Radii drawn to that Centre, do describe: alſo the Squares of the periodical Times in Ellipſes are in the ſeſquiplicate Ratio of the greater Axes, and drawing right Lines to the Bodies, which there touch the Orbits, and letting fall Perpendiculars from the common Focus to theſe Tangents; the Velocities of the Bodies are in a Ratio compounded of the inverſe Ratio of the Perpendiculars, and the direct ſubduplicate Ratio of the principal *Latus Rectums*.

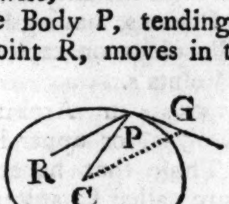
If a Body P, in revolving about the Centre S deſcribes the Curve A P Q, and the right Line P R touches



the Curve in P, and the Line Q R be drawn parallel, and infinitely near to S P, and Q T be drawn perpendicular to SP: then will the centripetal Force in any Point P of the Curve be reciprocally proportional to $\frac{\overline{SP}^2 \times \overline{QT}^2}{QR}$

If the periodic Times of Bodies, revolving in Circles, be as any Power R^n of the Radii, then the centripetal Force will be reciprocally as the Power R^{2n-1}. And contrarywiſe,

If the Body P, tending to any given Point R, moves in the Perimeter of any given conic Section,



whoſe Centre is C, and if the Line CG be drawn from the Centre C, parallel to the Ray R P, meeting the Tangent to the Section at G, the Law of the centripetal Force will be as $\frac{\overline{CG}^3}{RP^2}$

The Doctrine of centrifugal Forces was firſt mentioned by Mr. *Huygens*, in his *Horologium Oſcillatorium*, (at the end) which was publiſh'd *anno* 1673, where he has given a few eaſy Caſes in Bodies revolving in the Circumference of Circles, although without any Demonſtration. But Sir *Iſaac Newton*, in his *Principia*, was the firſt who has fully handled this Matter; at leaſt as far as regards the conic Sections. After him there have been ſeveral other Writers upon this Subject, as Mr. *Leibnitz*, Mr. *Varignon*, in the *Memoirs de l'Academie Royale des Sciences*; Dr. *Keil*, in the *Philoſophical Tranſactions*; Mr. *Bernoulli*, Mr. *Herman*, Mr. *Cotes*, in his *Harmonia Menſurarum*; Mr. *Maclaurin*, in his *Geometria Organica*; Mr. *Euler*, in his *Liber de Motu*; wherein this laſt conſiders the Curves deſcribed by a Body acted upon by centripetal Forces tending to ſeveral fixed Points.

CENTROBARYCAL, is what relates to the Centre of Gravity.

CEPHEUS, a Conſtellation in the Northern Hemiſphere, conſiſting of ſeventeen Stars.

CETUS, the *Whale*, a Southern Conſtellation, conſiſting of twenty-three Stars.

CHAIN, an Inſtrument of hard Wire, diſtinguiſhed into a hundred equal Parts, called Links, being uſed to meaſure Lengths in ſurveying of Land. They are of ſeveral ſorts; as

1. A Chain of a hundred Foot long, each Link being one Foot in Length, and at each tenth Foot there is a Plate of Braſs, with a Figure engraved upon it, ſhewing readily

 how

how many Links are from the Beginning of the Chain; and for more ease in reckoning, there is, or should be a brass Ring at every five Links, that is, one between every two Plates.

This Chain is most convenient for measuring of large Distances.

2. A Chain of sixteen Foot and a half in Length, and made so as to contain a hundred Links, with Rings at every tenth Link. This Chain is most useful in measuring small Gardens, or Orchards, by Perch or Pole Measure.

3. A Chain of four Poles or Perches in Length, (called *Gunter's Chain*) which is sixty-six Foot, or twenty-two Yards; for each Perch contains sixteen Foot and a half. This whole Chain is divided into a hundred Links; whereof twenty-five is an exact Perch or Pole; and for readily accounting, there is usually a remarkable Distinction by some Plate, or large Ring, at the end of twenty-five Links; also at the end of every tenth Link it is usual to fasten a Plate of Brass with Notches in it, shewing how many Links are from the Beginning of the Chain; and this Chain, of all others, is the most convenient for Land-Measure.

If two Lengths for finding the Area of any Parallelogram, Triangle, &c. in Acres, Roods, and Perches, be given in Chains and Links; and if the Links be above ten, you set the Chains and Links down with a Prick of the Pen between them; but if under ten, a Cipher be set before the Links, and you multiply the two Lengths like decimal Fractions. Then if five Figures towards the Right Hand be cut off, the Figures to the Left Hand will be Acres.

If the five Figures cut off be multiplied by 4, and five Figures be again cut off towards the Right Hand from this last Product, the rest will be Roods.

Lastly, if you multiply the five Figures cut off at the second Multiplication by 40; and five Figures being cut off, the rest will be square Perches or Poles.

Chain-Shot, is two Bullets, or rather Half-Bullets, fasten'd together with a Chain, their Use being chiefly to shoot down Masts, or cut the Rigging of a Ship, &c.

Chamber, is that Part of the Cavity of a great Gun, where her Carriage lies.

Chambranle, an Ornament in Masonry and Joiners Work, bordering the three Sides of Doors, Windows, and Chimneys, and is different according to the several Orders, and consists of three Parts, *viz.* the Top, called the *Traverse*, and the two Sides the *Ascendants*.

Chandeliers, in Fortification, are wooden Parapets made of two upright Stakes, about six Foot high, supporting divers Planks laid a-cross one another, or Bavins filled with Earth. They are made use of in Approaches, Galleries, and Mines, to cover the Workmen, and to hinder the Besieged from forcing them to quit their Labours. These differ from Blinds only in this, *viz.* that the former serve to cover the Pioneers before, and the latter to cover them over Head.

Chanel, in the *Ionic* Capital, is a Part somewhat hollow under the Abacus after the Listel, and lies upon the Echinus, having its Contours or Turnings on each Side to make the Voluta's.

Chapiters, in Architecture, are the Crowns, or upper Parts of a Pillar. Those that have no Ornaments, are called Chapiters with Mouldings, such as the *Tuscan* and *Doric*; the first whereof is the most simple, having its Abacus square, without any Mouldings; but the

Abacus of the other is crowned with an Astragal, and three Annulets under the Echinus. All those that have Leaves and carv'd Ornaments, are term'd Chapiters with Sculptures, and the first of them is the *Corinthian*, which is adorned with two Rows of Leaves; as also eight greater, and as many less Voluta's, placed under a Body called the Tympanum. These are called usually Capitals.

CHAPTRELS, in Architecture, are the same with Imposts, and signify those Parts on which the Feet of Arches stand, and their Height or Thickness is commonly equal to the Breadth of the lower Part of the Key-Stone.

CHARACTERISTICK *of a Logarithm.* See *Index*, or *Exponent*.

CHARACTERS (MATHEMATICAL,) are certain Marks invented by Mathematicians, for avoiding Prolixity, and more clearly conveying their Thoughts to Learners, and are as follow:

= is the Mark of Equality, (tho' *Descartes*, and some others use this ∞,) and signifies that the Quantities on each side of it are equal to one another; as, $a = b$, signifies that a is equal to b.

+ in Algebra, is a Sign of real Existence of the Quantity it stands before, and is called an affirmative and positive Sign, because it implies the Quantity to be of a positive and real Nature, and is directly contrary to the following Sign —.

This affirmative Sign is also the Mark of Addition, and signifies that the Quantities on each side of it are added together; as, if you see $a + b$, or $3 + 5$, it implies that a is added to b, or 3 added to 5, and is usually read a more b.

— This is the Note of Negation, negative Existence, or Non-entity; and whenever it stands alone before any Quantity, it shews that Quantity to be less than nothing, and therefore such Quantities are called negative Quantities; as -5 is a negative Quantity, or 5 less than nothing.

This negative Sign is also the Mark of Subtraction, and signifies, that the Quantities on each side of it, are subtracted from each other; as when you see $a - b$, it is read a less b, or b subtracted from a.

∽, or ⊥, is the Character expressing the Difference between two Quantities when it is not yet known which is the greater of the two; for here the Sign — cannot be used, because it supposes the Quantity following to be always less than that going before it.

× is the Sign of Multiplication; shewing, that the Quantities on each side the same are to be multiplied by one another; as $a \times b$, or $AB \times CD$, is to be read a multiplied by b, or AB multiplied by CD.

÷ is the Mark of Division, signifying, that the first of the two Quantities between it is divided by the latter; as $a \div b$, signifies that a is divided by b.

♋ is the Character of Involution, that is, of producing the Square of any Quantity, or of multiplying any Quantity into itself. In some Books of Algebra it is placed in the Margin, and shews, that the Step of the Equation, against which it stands, is to be multiplied into itself; or if it be a Square already, then to be raised to that Power that the Index set after the Character expresses.

ɯ is the Character of *Evolution*, that is, of extracting the Roots out of the several Powers, and is the Reverse of the last-mentioned Sign.

: : is the Mark of Geometrical Proportion disjunct, and is usually placed between two Pair of equal Ratio's; as $3 : 6 :: 4 : 8$ shews that 3 is to 6, as 4 to 8.

÷

∺ is the Mark of *Geometrical Proportion continued*, and implies the Ratio to be still carried on without any Interruption; as 2, 4, 8, 16, 32, 64, ∺.

√ is the Sign of Radicality, and shews (according to the Index of the Power, that is set over or after it,) that the Square, Cube or other Root, is extracted, or is to be so out of any Quantity; as $\sqrt{16}$, or $\sqrt[2]{16}$, or $\sqrt{(2)}\,16$, signifies the Square Root of 16, and $\sqrt[3]{16}$ is the Cube Root of 16.

⊏, or ⊐, is the Character of greater. And,

And ⊏, the Mark of the lesser of two Quantities.

‖ is the Sign for Parallels, and signifies that two Lines, or Planes, are equi-distant.

△ Triangle.

□ Square.

▯ ▭ Rectangle.

⊙ Circle, or the Sun.

≏ Equiangular, or Similar.

≑ Equilateral.

∠ Angle.

⌐ Right-Angle.

⊤ Perpendicular.

: : : is the Mark for Arithmetical Progression.

a. *b*=*c*. *d*. This, by *Wolfius*, signifies, that *a* is to *b*, as *c* to *d*.

The Characters of the seven Planets are,

♄ Saturn.

♃ Jupiter.

♂ Mars.

☉ Sol.

♀ Venus.

☿ Mercury.

☾ Luna.

The Characters of the Twelve Signs are,

♈ Aries.

♉ Taurus.

♊ Gemini.

♋ Cancer.

♌ Leo.

♍ Virgo.

♎ Libra.

♏ Scorpio.

♐ Sagittarius.

♑ Capricorn.

♒ Aquarius.

♓ Pisces.

The Characters of the Aspects are,

☌ Conjunction.

△ Trine.

□ Quartile.

⚹ Sextile.

☍ Opposition.

The chief Characters in Musick are,


Semibreve.

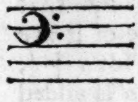

Minim.


Crochet.


Quaver.


Semi-Quaver.


Demi-Quaver.


Base-Cliff.

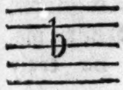

Treble-Cliff.


Tenor-Cliff.

Coun-


Counter-Tenor-Cliff.

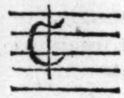

Sharp.

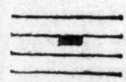

Flat.


Shake.

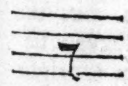

Beat.


Common Time ſlow.


Common Time ſwifter.


Minim, or Bar-Reſt.


Crochet-Reſt.


Quaver-Reſt.


Semi-Quaver-Reſt.


Contradiƈt.

Charged Cylinder, is that Part of the Chaſe of a great Gun, where the Powder and Ball are placed.

Charles's-Wain, ſeven Stars in the Conſtellation, called *Urſa Major*.

Charts, are Sea-Maps for the Uſe of Seamen, having the Sea-coaſts, Sands, Rocks, *&c.* depiƈted upon them, and are principally of two kinds, *viz.* the plain Chart, and *Mercator*'s or rather *Wright*'s. Of theſe you will ſee more under the Words *Plain Charts*, and *Mercator's Chart*.

Chase *of a Gun*, is its whole Length.

Chause-Trappes, or *Coltrops*, in Fortification, are Iron Inſtruments with four Spikes about four Inches long, made in ſuch a manner, that let them fall which way ſoever, one Point will always lie uppermoſt, like a Nail. They are uſually ſcatter'd and thrown into Moats and Breaches, to gall the Horſes Feet, and ſtop the haſty Approach of the Enemy.

Chemin *de Ronds*, in Fortification, is the way of the Rounds, or a Space between the Rampart and the low Parapet under it, for the Rounds to go about the ſame, with the *Fauſſe Bray*.

Chemise in Fortification, is a Wall that lines a Baſtion, or any other Bulwark of Earth, for its greater Support; or it is the Solidity of the Wall from the Talus to the Stone-Row.

Chersonesus, in Geography, ſignifies the ſame with *Peninſula*, and is a Part of the Land encloſed all round with Water, except one narrow Neck, by which it joins to the main Land, that being called an Iſthmus. Of theſe Cherſones there are reckon'd up fourteen by *Varenius*, in his *Geography*, *Chap.* 8. *Prop.* 10. *lib.* 1.

Chevaux de Frise, or *Friſeland Horſe*, is a large Joiſt, or Piece of Timber, about a Foot in Diameter, and ten or twelve in Length.

There

There are driven a great Number of wooden Pins into the Sides thereof, about six Foot long, crossing one another, and having their Ends arm'd with Iron Points. Their principal Use is to stop up Breaches, or to secure the Avenues of a Camp from the Inroads both of Horse and Foot. These are much the same with Turnpikes.

CHILIADS, are the Tables of Logarithms; being so called, because they were at first divided into Thousands. Thus, in the Year 1624. Mr. *Briggs* published a Table of *Logarithms* for twenty *Chiliads* of absolute Numbers, and afterwards for ten *Chiliads* more, and then for one more, that is, for thirty-one *Chiliads*.

And, in the Year 1628, *Adrian Vlacque* published this again with a Supplement of the Chiliads before omitted by Mr. *Briggs*; in all making up an hundred and one *Chiliads*.

CHILIOGEN, a regular plain Figure, of a thousand Sides and Angles.

CHORD, in general, is a Right-Line drawn from one Part of an Arch of a Circle to the other. But the

CHORD *of an Arch*, is a Right-Line joining the Extreams of that Arch.

1. A *Chord* is bissected by a Perpendicular drawn to it from the Centre of the Circle.

2. *Chords* in the same Circle, whose Arches are equal, are likewise themselves equal.

3. *Unequal Chords* in the same Circle, are not proportional to their Arches.

CHOROGRAPHY, is a particular Description of some Country; as of *England*, *France*, or any Part of them, &c.

CHROMATIC, a Term in Music, being the second of the three Kinds, which abounds in Semi-Tones and contains only the least diatonical Degrees.

CHRONOLOGY, as it is commonly taken, is the Arithmetical Computation of Time for historical Uses; that thereby the Beginnings and Endings of Princes Reigns, the Revolutions of Empires and Kingdoms, Battles, Sieges, or any other memorable Actions, may be truly stated.

CHRONOSCOPE, the same as a *Pendulum*, to measure Time with.

CHRYSTALLINE HEAVENS. These, in the *Ptolemaic System*, were two: Whereof one served them to explain the slow Motion of the fixed Stars, and caused them (as they thought) to move one Degree Eastwards, in the same space of seventy Years.

And the other helped them out in solving a Motion, which they called the *Motion of Trepidation*, or *Libration*; by which they imagined they swag from Pole to Pole.

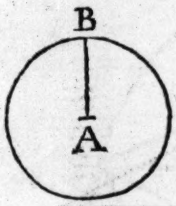
CIMA, or *Cymaise*, is what we call, in *English*, an *Ogee*, *Ogive*, or barely *O G*; by which we mean a Moulding waved on its Centre, concave at the top, and convex at the bottom, and which makes the uppermost Member, and, as it were, the Cime or Top of large Cornices. Of these there are two Kinds: In the one, that Part which has the greatest Projecture, is concave, being term'd Doucine, or an Upright *Ogee*. In the other, the convex Part has the greatest Projecture.

CINCTURE, in Architecture, is the same with *Apophygee*.

CIRCLE, is a plain Figure, comprehended under one Line only, to which Bounding Line all Right Lines, that are drawn from a Point in the middle of it, are equal to one another. And it may be supposed to be generated thus:

If

If the Line A B be faſtened at one End to the Point A, and the other Point or End B thereof be mov'd round in a Plane till it is return'd to the Place from whence it went, that Line, in thus moving, will deſcribe a Circle; and the Point

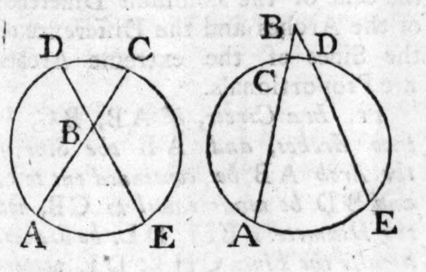


or End B, the Circumference thereof: And the Point A will be the Centre.

1. The Area of any Circle is equal to a Rectangle under the Diameter, and one Quarter of the Circumference.

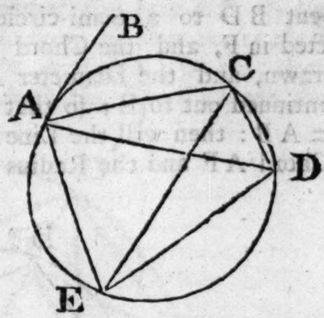
2. The Diameter of a Circle is proportional to the Circumference.

3. If two Right Lines, A C, D E, terminating in the Periphery of a Circle, do interſect each other in the Point B, either within the Circle, or (being continued) without it, as in the ſecond Figure, then $AB \times BC = BE \times BD$.



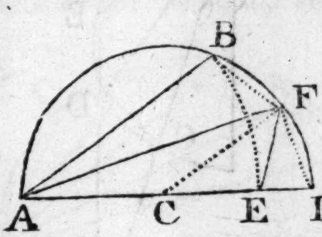
4. The Angle B A C made by the Tangent A B, and the Chord A C is equal to any Angle A E C, or A D C, in the Alternate Segment A E C of the Circle.

5. Let A C D E be a Quadrilateral Figure in the Circle, and the Lines A D, E C, the Diagonals, then $AC \times ED + AE \times CD = AD \times CE$.



6. In a Circle the Sine of any Arch is equal to half the Chord of twice that Arch.—The Square of the Chord of any Arch is equal to the Rectangle under the verſed Sine of that Arch, and the Diameter of the Circle.—The Sine of an Arch is to the Co-ſine of that Arch, as the Radius is to the Tangent of that Arch.—The Radius is a mean Proportional between the Sine of an Arch and the Co-ſecant of that Arch.—The Radius is a mean Proportional between the Tangent of an Arch, and its Co-tangent.—As the Radius is to a mean Proportional between the Aggregate of the Radius and Sine of an Arch, and the Difference between the Radius and that Sine; ſo is twice that Sine to the Sine of double that Arch.

7. In a Semi-circle, if A B be the Chord of an Arch, and F D the Chord of $\frac{1}{2}$ the Complement of that Arch to a Semi-circle; then will the Difference between the Diameter A D and the Chord A B, the

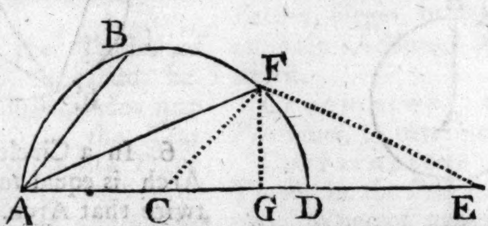


Chord F D, and the Radius A C, be continual Proportionals.

7. In a Semi-circle, if A B be the Chord of any Arch, and its Complement B D to a Semi-circle be bissected in F, and the Chord A F be drawn, and the Diameter A D be continued out to E; so that D E be = A B: then will the Line D E the Chord A F and the Radius A C be continual Proportionals. Consequently if the Radius be = 1; we shall have

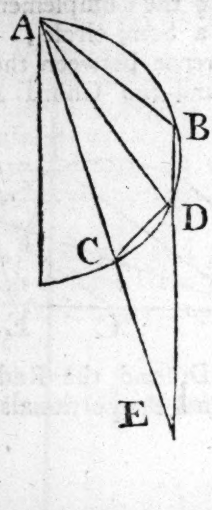
$$\sqrt{2-\sqrt{2+\sqrt{2+\sqrt{2+\sqrt{3}}}}}$$

for the Side of a regular Polygon of 96 Sides.



8. The versed Sine of an Arch drawn into $\frac{1}{2}$ the Radius, is equal to the Square of the Sine of $\frac{1}{2}$ that Arch.— The Sine of an Arch drawn into the Radius, is equal to twice the Sine of $\frac{1}{2}$ that Arch drawn into its Co-sine.— The Square of the Radius, the Square of the Chord of any Arch, the Difference of the Squares of the Diameter, and of that Chord and the Square of the Chord of twice that Arch, will be proportional.— As the Difference between the Square of the Radius and the Square of the Tangent of an Arch less than 45 Deg. is to twice the Square of the Radius; so is the same Tangent to the Tangent of twice that Arch.

9. If an Angle C A B standing

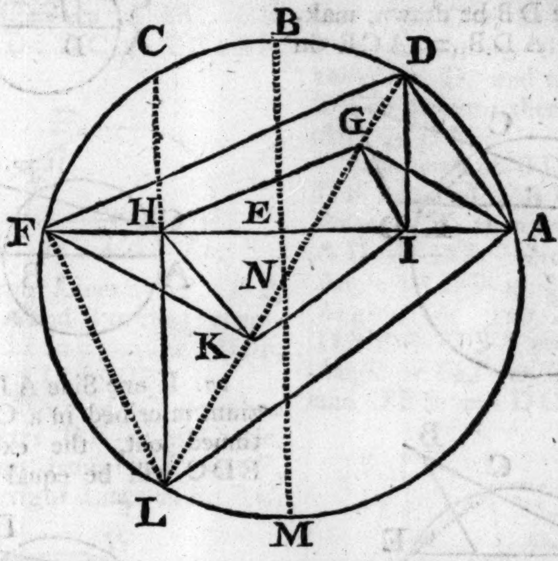


upon the Circumference of a Circle be bissected by the right Line A D, and A C be drawn to E, so that D E the Continuation of B D be equal to A D, then will C E = A B.

10. Thrice the Square of the Radius drawn into the Chord of the third Part of an Arch, lessen'd by the Cube of this Chord, is equal to the Square of the Radius drawn into the Chord of three times that Arch.— If three Arches of a Circle be equi-different, *viz.* Arithmetical Progressionals, the Radius, twice the Co-sine of the middle Arch, the Sine of the common Difference of the Arches and the Difference of the Sines of the extreme Arches are Proportionals.

11. *In a Circle, if* A B, B C, *be two Arches, and* A E *the Sine of the Arch* A B *be continued out to* F, *and* B D *be made equal to* C B, *and the Diameters* B M, D L, *be drawn, as also the Lines* C H L, D I, *perpendicular to* F A. *Moreover, if the Chords* F D, D A, A L, L F, *be drawn, and the Lines* H G, G A, G I, I K, K F, K H. *I say* 1. E I *will be the Sine of* C B, (B D) 2. A H (F I) *the Sine of the Arch* A B + *the Sine of the Arch* B C. 3. F H (A I) *the Sine of the Arch* A B

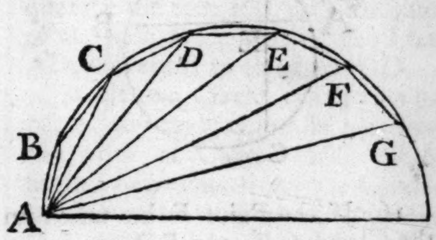
AB — *the Sine of the Arch* BC. 4. DK *the versed Sine of the Arch* AB + *the Arch* BC. 5. DG *the versed Sine of the Arch* AB — *the Arch* BC. 6. LK *the co-versed Sine of the Arch* AB + *the Arch* CB. 7. LG *the co-versed Sine of the Arch* AB — *the Arch* BC. 8. FD *the Chord of the Arch* AB + *the Arch* CB, *being equal to twice the Sine of* $\frac{1}{2}$ *the Arch* AB + *the Arch* CB. 9. AD *the Chord of the Arch* AB



— *the Arch* CB *equal to twice the Sine of* $\frac{1}{2}$ *the Arch* AB — *the Arch* CB. 10. FN *the Sine of the Arch* AB + *the Arch* BC. 11. AG *the Sine of the Arch* AB — *the Arch* BC. 12. LH *the Co-sine of the Arch* AB + *the Co-sine of the Arch* BC. 13. DI *the Co-sine of the Arch* AB — *the Co-sine of the Arch* BC, *equal to the versed Sine of the Arch* AB — *the versed Sine of the Arch* BC. 14. $\frac{1}{2}$ LF *the Co-sine of* $\frac{1}{2}$ *the Arch* AB + *the Arch* BC. 15. $\frac{1}{2}$ LA *the Co-sine of* $\frac{1}{2}$ AB — *the Arch* BC. *And,* 16. *Lastly, the Trapeziums* ALHG, FDIK, LFHK, *and* AIGD, *will be similar.*

All the Articles, except the last, evidently enough follow from the Construction and the Definition of Sines, Co-sines, versed Sines, and Chords; and from *n.* 6. of this, that the Chord of any Arch is twice the Sine of double that Arch. As to the last, concerning the Similarity of the Trapeziums, it follows, because each of them have two Angles at the Circumference, *viz.* the one = $\frac{1}{2}$ AB + BC, the other equal to $\frac{1}{2}$ the Complement of AB + BC; as also two right-angled Triangles form'd by the respective Diagonals and Sides, which are respectively similar: Therefore the Sides about the equal Angles will be proportional; consequently the Trapeziums ALHG, FDIK, LFHK, and AIGD, are similar.

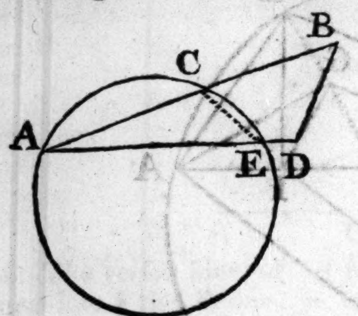
12. If the Arches AB, BC, CD, DE, EF, *&c.* be equal, and the

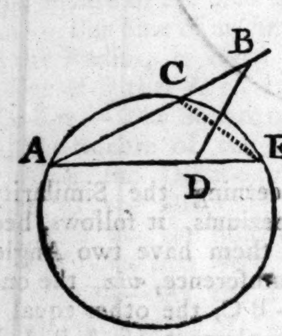


Chords

Chords AB, AC, AD, AE, &c. be drawn; then it will be $AB : AC :: AC : AB + AD :: AD : AC + AE :: AE : AD + AF :: AF : AE + AG$.

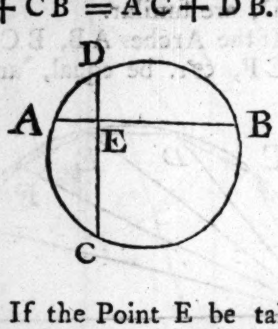
17. If from a Point D in a Chord AE, the Line DB be drawn, making the Angle $ADB = ACE$ in



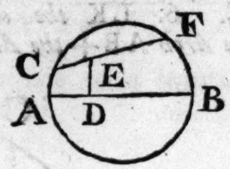


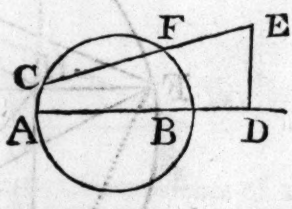
the Segment ACE, of which AE is the Baſe; and if the right Line ACB be drawn; then will $AB \times AC$ be $= \overline{AE}^2$.

15. If the Chords AB, CD, be at right Angles; the oppoſite Arches $AD + CB = AC + DB$.

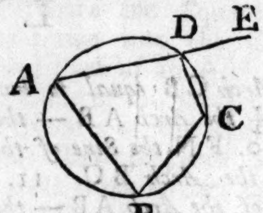


16. If the Point E be taken in the Chord CF, and ED be drawn perpendicular to the Diameter AB; then will $AD \times DB = CE \times EF + \overline{DE}^2$.





17. If one Side AD of a Trapezium inſcribed in a Circle be continued out, the external Angle EDC will be equal to the Angle

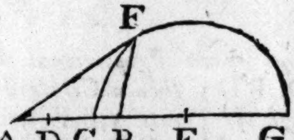


B, oppoſite to the Angle ADC its Complement to a Semi-circle.

18. If the two Diagonals of a Trapezium, inſcribed in a Circle, cut one another at right Angles, the Sums of the Squares of each Pair of oppoſite Sides will be equal. —— and the Aggregate of the four Squares of the Segments of thoſe Diagonals will be equal to the Square of the Diameter of the Circle.— If any Tangent meets the Diameter continued out, and from the Point of Contact a Perpendicular be let fall upon the Diameter, the Rectangle under the Diſtance of this Perpendicular from the Centre, and the Point where the Tangent cuts the Continuation of the Diameter, will

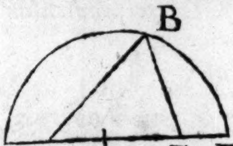
will be equal to the Square of the Radius.

19. If the Point B be taken in the Diameter C G of a Semicircle, and the Point A in that Diameter continued out ſuch, that making A D, the Difference of A C, C B, it ſhall be A D : D C :: C B : B E.



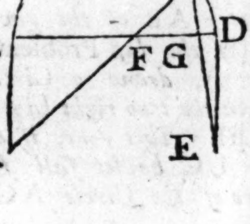
Then any two Lines A F, F B, drawn from A and B to the Circumference, will be in a conſtant Ratio, *viz.* that of A C to C B.

20. If the Points A, C, be taken in the Diameter D E of a Circle, equally diſtant from the Centre F, and any two right Lines A B, B C,



be drawn from them to the Circumference of the Circle; the Sum of the Squares of theſe Lines will be equal to $\overline{AE}^2 + \overline{CE}^2$.

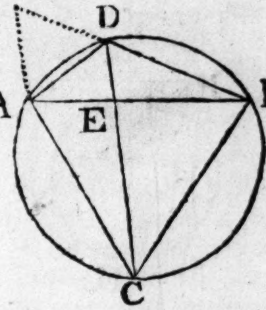
21. In a Semicircle, if from A E the Ends of the right Lines A B, E D, each perpendicular to the Diameter B D, and equal to the Side of an inſcribed Square or the Chord of 90 Degrees, be drawn the right Lines A C, E C, to any Point



C in the Periphery, cutting B D in F, G; then will $\overline{BG}^2 + \overline{FD}^2$ be $= \overline{BD}^2$.

22. If A B C be an equilateral Triangle inſcribed in a Circle, and any right Line be drawn from the Point C, cutting the Arch A B in the Point D, and the Chords A D, D B be drawn; then will C D be $=$ A D $+$ D B.

Continue out B D to F, ſo that D F be equal to A D, and join the Points A, F, then will F B be equal A D $+$ D B. Now becauſe the Angle A D B is $\frac{2}{3}$ of two right Angles, or 120 Degrees, ſince D A B $+$ D B A $= \frac{2}{3}$ of one right Angle or 60; for D A B $=$ D C B, and D B A $=$ D C A. Therefore

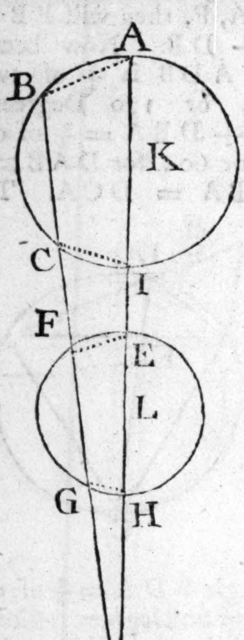


the Angle F D A $= \frac{2}{3}$ of one right Angle or 60 Degrees. Conſequently the Triangle A F D will be equilateral; and becauſe the Angles A C D, A B D, ſtanding upon the Arch A D are equal, and the Sides A C, A B, as alſo A D, A F; therefore the Triangles C A D, A F B, will be equal and ſimilar. Conſequently the Side F B will be equal to the Side D C, that is, the Lines A D, B D equal to the Line C D.

23. If two Circles touch one another, any right Line drawn from the Point of Contact will cut off ſimilar Segments from the Circles, and it will be divided at the Point of Contact in the Ratio of the Diameters.

meters.—If a right Line joining the Centres of two Circles be divided in the Ratio of their Semidiameters, any right Line drawn thro' the Point of Division will cut off similar Segments from those Circles.

24. If a right Line MA be drawn through the Centres L, K, of two Circles, and the Point M be such, that any right Line MB drawn from it, and cutting the said Circles

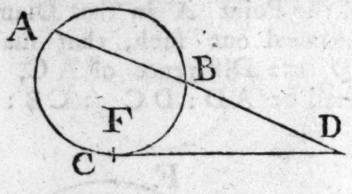


does cut off similar Segments GF, CB, from them; I say MA × MH = MG × MB. Note, the Point M may be taken between the Circles.

25. From the three last Theorems may be solved the following elegant and useful Theorems of *Vieta*'s, relating to the Description of a Circle. The Problems are these:

Prob. 1. To describe a Circle through two given Points A, B, that shall touch a right Line CD given in Position.

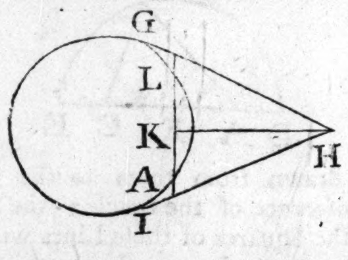
Join the given Points A, B, *and continue out the Lines* AB, CD, *to meet each other, as at* D; *make*



DF *a mean Proportional between* A, D, BD; *then a Circle described through the Points* A, B, F, *will touch the right Line* CD *in the Point* F, *for* $\overline{FD}^2 = AD \times BD$.

Prob. 2. To draw a Circle thro' a given Point A, to touch two right Lines GH, IH, given in Position.

Continue out the right Lines GH, IH, *to meet in the Point* H, *and bissect the Angle* GHI *by the right Line* KH; *from* A *draw the right Line* AKL *perpendicular to* KH.

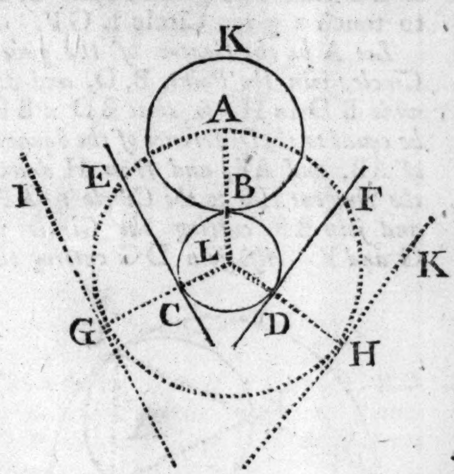


Then if a Circle be described (*by* Prob. 1.) *thro' the Points* A, L, *to touch either of the Lines* GH, IH, *it will be the Circle required.*

Prob. 3. To draw a Circle CBD, to touch a given Circle KB, and two right Lines EC, FD, given in Position.

Draw the right Lines IG, KH, *parallel to* EC, FD, *and at a Distance from them equal to the Semidiameter* AB *of the given Circle; and* (*by the last* Problem) *thro' the Point* A, *draw a Circle* AGH, *to touch the two right Lines* IG, KH, *in* G, H. *This done, if a Perpendicular* LC *be let fall from* L, *the Centre of the Circle* AGH *to the Line*

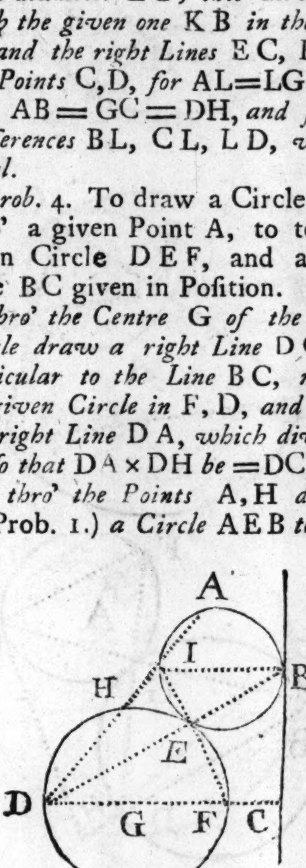
Line EC, *and a Circle* BCD *be drawn about the Centre* L, *with the*

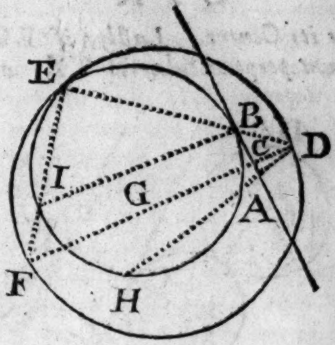


Semi-diameter LC; *this Circle will touch the given one* KB *in the Point* B, *and the right Lines* EC, FD, *in the Points* C, D, *for* $AL = LG = LH$, *and* $AB = GC = DH$, *and so their Differences* BL, CL, LD, *will be equal.*

Prob. 4. To draw a Circle AEB thro' a given Point A, to touch a given Circle DEF, and a right Line BC given in Position.

Thro' the Centre G *of the given Circle draw a right Line* DC *perpendicular to the Line* BC, *meeting the given Circle in* F, D, *and draw the right Line* DA, *which divide in* H, *so that* $DA \times DH$ *be* $= DC \times DF$, *and thro' the Points* A, H *describe* (*by* Prob. 1.) *a Circle* AEB *to touch*





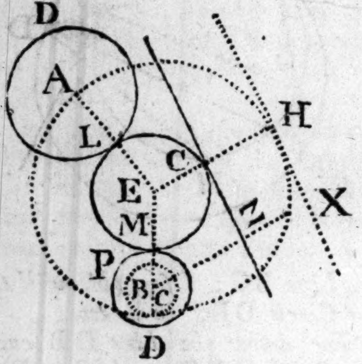
the Line BC: *I say, this will touch the Circle* DEF *in* E *too.*

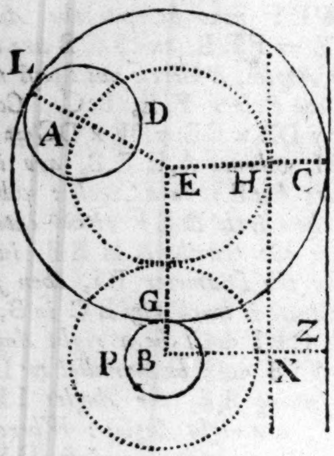
For draw the Line DB *cutting the Circle* DEF *in the Point* E, *and join* FE; *now because the Angles* $DFE = FEB$, *and* FCB *are each right Angles, a Circle will pass thro' the four Points* F, E, B, C. *Consequently* $DB \times DE = DF \times DC = DA \times DH$, *whence* A, H, E, B, *are in a Circle; but* E *is in a Circle: wherefore the Circle* DEF *either cuts or touches the Circle* AHEB, *in* E. *Draw the Diameter* BI, *then since this Circle is touch'd by* BC *in* B, *the Angle* CBI *will be a right Angle; and so* IB *will be parallel to* DC, *and joining* IE, *the Angles* IEB, DEF, *are right Angles: Wherefore* IE, EF, *coincide; and so* DEF, BEI, *are two similar Triangles, and the Circles circumscribing them touch in the Point* E.

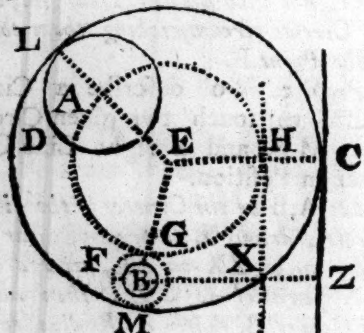
Prob. 5. To describe a Circle LCM to touch two given Circles DL, MP, and a right Line CZ given in Position.

Let A, B *be the Centres of the given Circles, draw* BZ *perpendicular to* CZ, *make* $ZX = AL$, *and draw* HX *parallel to* CZ; *then about the Centre* B, *with a Radius equal to the Aggregate or Difference of the Radius's of the first and second Circles describe a Circle* MG, *and thro' the Centre* A *draw a Circle* (*by* Prob. 4.) *to touch the Circle* MG *in* G, *and the Right Line* HX *in* H, *and let*

E *be its Centre. Lastly, if* E C *be drawn perpendicular to* C Z, *and a*





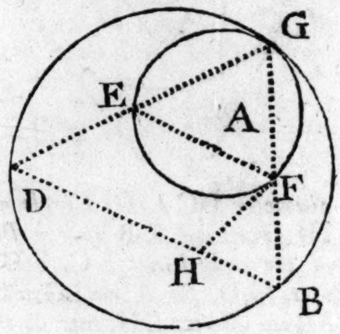


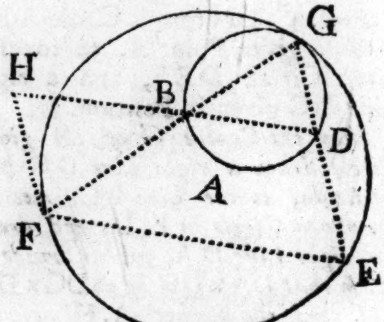
Circle L C M *be described about the Centre* E, *with the Radius* E C, *this Circle will touch the given ones* D L, M E, *and the Right Line* C Z. *The Reason is sufficiently evident from the Construction.*

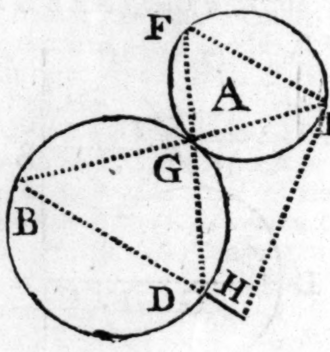
CIR

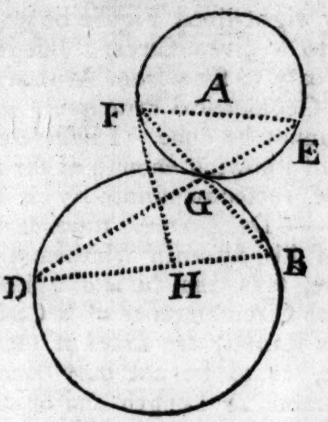
Prob. 6. To describe a Circ D G B thro' two given Points B, D to touch a given Circle E G F.

Let A *be the Centre of the given Circle, join the Points* B, D, *and divide* B D *in* H, *so that* B D × B H *be equal to the Difference of the Squares of* A B, *and* A F, *and from* H *draw the Tangent* H F *to the Circle* E G F, *and join* B F *cutting the Circle in* G *and* F. *Also join* D G *cutting the*







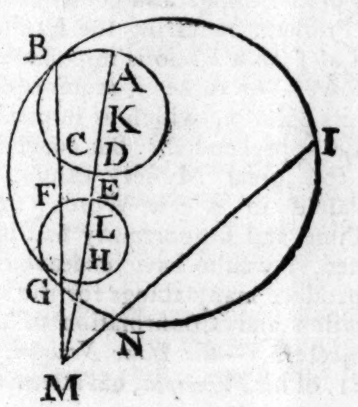


Circle in E; *then if a Circle* GBD *be described about the three Points* G, B, D; *the same will be that required.*

For because $BD \times BH = \overline{AB}^2 - \overline{AF}^2$, *it easily follows* (37. 3.) *that the Points* D, G, F, H, *are in a Circle: and so the Angle* DGB *of the Quadrilateral Figure* DGFH = *Angle* FHB; *and the Angle* GDB *or* GEF = (32. 3.) *Angle* HFB; *therefore* EF, DB *are parallel: and so the Triangles* GDB, GEF *will be similar. Consequently the Circle* BGD *touches the given Circle* EGF *in* G, *and passes through the given Points* B, D.

Prob. 7. To describe a Circle GBI thro' a given Point I, to touch two given Circles BA, FE.

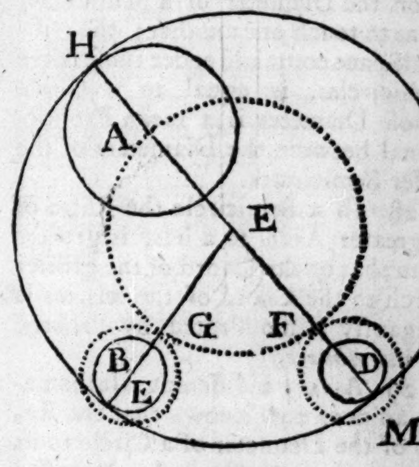
Join the Centres K, L, *of the*



given Circles, and in KL *take the Point* M *such, that any Right Line* BM *being drawn, shall cut off similar Segments* GF, CB, *from the Circles; then draw the Right Line* MI, *and divide it so in* N, *that* $MI \times MN = MH \times MA$; *and thro'* I, N, *draw a Circle* BGI *touching the Circle* ABCD, *and let* B *be the Point of Contact. Join* BM *cutting the Circles in* B, C, F, G; *then* $MG \times MB = MH \times MA = MN \times MI$; *wherefore the Points* N, I, B, G *are in the same Circle. But* G *is also in the Circle* EFGH; *wherefore the Circles* EFGH, IBGN, *do mutually cut one another, or touch in* G. *But* BNI, BCD, *touch in* B; *wherefore the Segments* BG, BC, *are similar. But* FG, BC, *are similar; wherefore* FG, BG, *are similar: and so the Circles* EFG, IBG, *do touch in the Point* G.

Prob. 8. To describe a Circle MLH to touch three given Circles whose Centres are A, B, D.

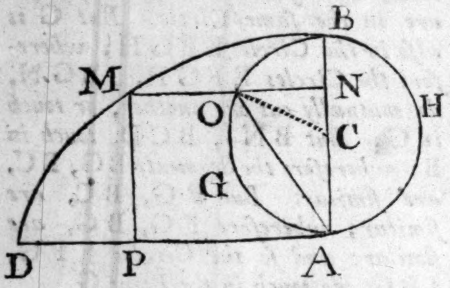
About the Centre D *describe a Circle with a Radius equal to the Difference or Sum of the Radii of the first and third Circles, and about the Centre* B *with the Radius* BG *equal*



to the Sum or Difference of the Radii of the first and second Circles; and through A *describe a Circle* AGF, *touching*

touching the Circles B, D, *in the Points* G, F, *then a Circle described about* E, *with a Radius equal to* AE + AH, *will touch the three given Circles in the Points* H,M,F. There are more Cases of this Problem, which it is easy to supply.

26. If it be required to divide a given Circle into two Segments, having a given Ratio of R to S; suppose BMD to be a Semi cycloid, whose Base is AD, and Altitude



AB. Divide AD in P in such manner, that AP : AD :: S — R : S + R; and from P draw PM perpendicular to AD, and MN parallel to it, and draw the Right Line AO; then will the Segments AGO, AHO, be to one another as R to S.

27. If two Semicircles be described upon the Diameter of a Semicircle, so as to touch one another; the trilinealSpace contain'd under those three Semicircles, is equal to a Circle whose Diameter is a mean Proportional between the Diameters of the lesser Semicircles.

28. In a Semicircle the Ratio of a greater Arch to a less, is greater than that of the Chord of the greater Arch to the Chord of the less, as is elegantly demonstrated by *Ptolemy*, in his *Almagest*.

29. A very indifferent Mathematician does now know, that the Ratio of the Diameter of a Circle to its Circumference cannot be expressed in Numbers exactly; nor can two Right Lines be drawn expressing that Ratio: neither can a Square, or any right-lined Figure be made equal to a given Circle. But it is not so easy to shew from Arithmetical or Geometrical Principles, why this cannot be done. I believe our Want of knowing enough of the nature of Incommensurability is the cause.——Dr. *Barrow*, towards the end of his fifteenth Mathematical Lecture, says, that he is of opinion, that the Circumference of a Circle, and its Radius, are Lines of such a nature, as to be not only incommensurable in Length and Square, but also in Length, Square, Cube, Biquadrate, *&c. ad infinitum:* for (continues he) the Side of the inscribed Square is incommensurable to the Radius, and the Square of the Side of the inscribed Octagon is incommensurable to the Square of the Radius; and consequently the Square of the octagonal Perimeter is incommensurable to the Square of the Radius: and thus the Ambits of all regular Polygons, inscribed in a Circle, may have their superior Powers incommensurate with the co-ordinate Powers of the Radius; from whence the last Polygon, that is, the Circle itself, does seem to have its Periphery incommensurate with the Radius. Which, if true, will put a final stop to the Quadrature of the Circle, since the Ratio of the Circumference to the Radius, is altogether inexplicable from the nature of the thing, and consequently the Problem requiring the Explication of such a Ratio is impossible to be solved, or rather it requires that for its Solution which is impossible to be apprehended. But concludes he, this great Mystery cannot be explain'd in a few Words: But if Time and Opportunity had permitted, I would have endeavoured to produce many things for the Explication and Confirmation of this Conjecture.—Sir *Isaac Newton*, in *Lib*. 1. of his *Principia*, has attempted at

at a Demonstration, to show the Impossibility of the general Quadrature of oval Figures, by the Description of a Spiral, and the Impossibility of determining the Intersections of that Oval and Spiral (which must be the case, if the Oval is squareable) by a finite Equation. But I must confess this Method is not so clear and evident as might be wish'd.

30. There have been many Persons, even many Ages ago, as well as in these later Times, who have given themselves much pain, and at the same time greatly exposed their own Ignorance, by publishing pretended Quadratures of the Circle; and amongst the Moderns, no one has been more eminent than our own Countryman Mr. *Hobbs*, who notwithstanding his Skill in some things, yet has shewn a most obstinate Ignorance in this.—The Great *Archimedes*, in *Libro de Dimensione Circuli*, has first given a near Ratio of the Diameter of a Circle to its Circumference in small Numbers, being that of 7 to 22: but his Demonstration is long and tedious. Many Ages after him, *Van Ceulen*, a *Dutchman*, in *Libro de Circulo & Adscriptis*, gave us a nearer Ratio in larger Numbers, expressed by 36 Places of Figures; and was so fond thereof, that he order'd it to be put upon his Grave-Stone. After him, *Willebrord Snell*, another *Dutchman*, in his *Cyclometricus*, gives the same Ratio to 36 Places of Decimals, being that of .1 to 3. 14. 15926, 53589, 79323, 84626, 43383, 27950, 28958 nearly: which they effected by the continual Bissection of an Arch of the Circle, after a manner most exceedingly troublesome and laborious. After these came the indefatigable Mr. *Abraham Sharp*, who gave that Ratio to 72 Places of Decimals, in a sheet of Paper, published about the year 1706. But the very ingenious Mr. *Machin* has carried this Ratio the nearest to the Truth of any that have ever been published, as may be seen in Mr. *Jones*'s *Synopsis*, being to 100 Places of Decimals.

31. The Ratio of the Diameter of a Circle to the Circumference will be nearly as 7 to 22, or 106 to 333, or 113 to 355, or 1702 to 5347, or 1815 to 5702, or 100000 to 314159. The second being more exact than the first, and the next foregoing one still more so than the next following.—The Investigation of these Ratio's chiefly depends upon the Theorem laid down under the word Ratio.

32. If the Radius of a Circle be 1. the Length of an Arch of 30° will be $= \frac{1}{\sqrt{3}} \times \overline{1 - \frac{1}{3 \times 3} + \frac{1}{5 \times 9} - \frac{1}{7 \times 27} + \frac{1}{9 \times 81}}$, &c. and twelve times this will be equal to the whole Circumference.—If to six times the Radius be added $\frac{1}{10}$ part of the side of the inscribed Square, the Sum will be nearly $\frac{1}{2}$ the Circumference of the Circle; but less, that is, the Diameter being 2, the Semi-circumference will be $3 + \frac{1}{10}\sqrt{2}$ nearly.

33. If to six times the Radius be added $\frac{1}{5}$ part of the side of the inscribed Square, the Sum will be almost equal to the whole Circumference of the Circle; that is, the Diameter being 2, the whole Circumference will be $6 + \frac{1}{10}\sqrt{2}$ nearly.

34. If BC be the Diameter of a Circle, and the Half Circumference

BC be divided into three equal Parts BE, EF, FC, and from EF be drawn the Right Lines ED, FD to the Point D, bissecting the other Semi-periphery BDC; then will GD + GH be nearly equal to a Quadrant of that Periphery: but less, though the Difference does not exceed the $\frac{1}{1000}$ Part of the Diameter; that is, if BC be 2, the whole Circumference will be nearly =

$$\frac{8\sqrt{2+\sqrt{3}}}{2+\sqrt{3}} + 8$$

35. If the Chord of a Quadrant be 1. the Length of the Arch of a Quadrant will be $= 1 + \frac{1}{3} - \frac{1}{5} - \frac{1}{7} + \frac{1}{9} + \frac{1}{11} - \frac{1}{13} - \frac{1}{15}$, &c. This Series was first taken notice of by Dr. *Gregory* and Mr. *Leibnitz*; but Sir *Isaac Newton*, in his Observations upon the same, says, it is of no use, by reason of the very small Convergency thereof. For he says, in order to get the Length of a quadrantal Arch to 20 Places of Decimals, there will be occasion for nearly 5000000000 Terms of that Series: to compute which it would require a thousand Years.

36. If the Diameter of a Circle be 1, and $a = \frac{1}{2}$, then will the whole Circumference be the Sum of these three Series's,

$$\frac{a}{1} - \frac{a^3}{3} + \frac{a^5}{5} - \frac{a^7}{7} + \frac{a^9}{9}, \text{&c.}$$
$$+ \frac{a^2}{1} + \frac{a^5}{3} - \frac{a^8}{5} - \frac{a^{11}}{7} + \frac{a^{14}}{9} + \frac{a^{17}}{11}, \text{&c.}$$
$$+ \frac{a^4}{1} - \frac{a^{10}}{3} + \frac{a^{16}}{5} - \frac{a^{22}}{7} + \frac{a^{28}}{9}, \text{&c.}$$

37. If the Radius of a Circle be 1, and a be $= 2\sqrt{3}$. then will $\frac{1}{2}$ the Circumference be $a - \frac{1}{3}\frac{3}{9}a + \frac{1}{5}\frac{a}{9} - \frac{1}{7}\frac{3a}{9^2} + \frac{1}{9}\frac{a}{9^2} - \frac{1}{11}\frac{3a}{9^3} + \frac{1}{13}\frac{a}{9^3}$, &c. or as 1 is to $\overline{\frac{16}{5} - \frac{4}{239}} - \frac{1}{3}\overline{\frac{16}{5^3} - \frac{4}{239^3}} + \frac{1}{5}\frac{16}{5^5} - \frac{4}{239^5}$, &c. so is the Diameter of a Circle to its Circumference.

38. If a be the Chord of an Arch of a Circle, and b the Chord of $\frac{1}{2}$ that Arch, then will $\frac{8b-a}{3}$ be nearly equal to the Length of the Arch of the Circle.

39 Let r be the Radius of a Circle, a any Arch, c the Chord, s the Sine, v the versed Sine, and t the Tangent of that Arch; then (1.) will a be nearly =

$$\frac{4\sqrt{2r^2 - 2r\sqrt{r^2-s^2}} - s}{3}.$$

(2.) $a = \overline{1 + \frac{4r}{r+\sqrt{r^2-s^2}}} \times \frac{s}{3}$. (3.) $a = \overline{2 + \frac{r}{\sqrt{r^2-s^2}}} \times \frac{s}{3}$. (4.) $a = \frac{3rs}{2r+\sqrt{r^2-s^2}}$.

(5.) $a = \frac{2r+\sqrt{r^2-s^2}}{r+2\sqrt{r^2-s^2}} \times s$.

(6.) $a = \frac{14rs + s\sqrt{r^2-s^2}}{9r+6\sqrt{r^2-s^2}}$.

(7.) $a = t - \frac{t^3}{3r^2} + \frac{t^5}{5r^4} - \frac{t^7}{7r^6} + \frac{t^9}{9r^8}$, &c. (8.) $a = s + \frac{1\times1\times s^3}{2\times3\times r^2} + \frac{1\times1\times3\times3\times s^5}{2\times3\times4\times5\,r^4} + \frac{1\times1\times3\times3\times5\times5\,s^7}{2\times3\times4\times5\times6\times7\,r^6}$, &c.

(9.) and $S = a - \frac{1}{6}\frac{a^3}{r^2} + \frac{1\,a^5}{120\,r^4}$ −

$$-\frac{1a^7}{5040r^6}+\frac{1a^9}{362880r^8}, \text{\&c.}$$

$$(10.)\ a=\sqrt{2rv}\times\overline{1+\frac{v}{6\times 2r}+\frac{3v^2}{40\times 4dd}+\frac{5v^3}{112\times 8d^3}, \text{\&c.}}$$

$$(11.)\ v=\frac{aa}{2r}-\frac{a^4}{24r^3}+\frac{a^6}{720r^5}-\frac{a^8}{40320r^7}, \text{\&c.}$$

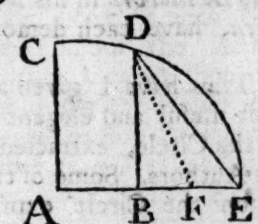
40. As 14 is to 11, ſo is the Square of the Diameter of a Circle to the Area thereof nearly.—— In Dr. *Wallis*'s *Arithmetic of Infinites*, we firſt find infinite Series's expreſſing the Ratio of a Circle to the Square of its Diameter; there are two of them. (1.) As $\frac{3\times 3\times 5\times 5\times 7, \text{\&c.}}{2\times 4\times 4\times 6\times 6\times 8, \text{\&c.}}$ is to 1; ſo is the Circle to the Square of its Diameter: This was found out by him. (2) As

$$1+\frac{1}{2}+\frac{9}{2}+\frac{25}{2}+\frac{49}{2}+\frac{81}{2}, \text{\&c.}$$

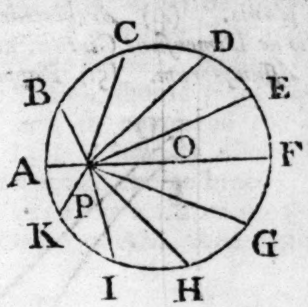
is to 1, ſo is the Square of the Diameter of a Circle to the Circle itſelf; or, as

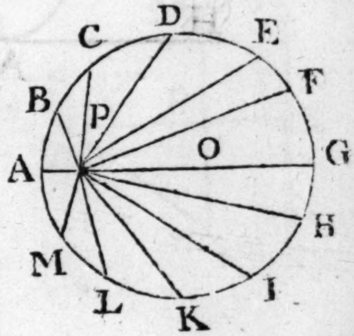
$$1+\cfrac{1}{2+\cfrac{9}{2+\cfrac{25}{2+49+\frac{81}{2}, \text{\&c.}}}}$$

is to 1; ſo is the Square of the Diameter of a Circle, to the Circle itſelf: this is the *Lord Bronker*'s, as *Wallis* himſelf ſays.—— If the Diameter of a Circle be 1, the Area will be $=1-\frac{1}{6}-\frac{1}{40}-\frac{1}{112}-\frac{5}{1152}-\frac{7}{2816}$, &c.——— If the Diameter of a Circle be 1, the Area of the whole Circle will be $=1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\frac{1}{11}$, &c. The former of theſe is Sir *Iſaac Newton*'s, and the latter Mr. *Leibnitz*'s.—— If the Radius AE of a Circle be r, and AB be x; then will the Area ACDB be $=rx-\frac{x^3}{6r}-\frac{x^5}{40r^3}-\frac{x^7}{112r^5}-\frac{5x^9}{1152r^7}$, &c. Or, if AE be $\frac{1}{2}$, and BE, x; the Area BDE will be $=x^{\frac{1}{2}}\times\overline{\frac{2}{3}x-\frac{1}{5}x^2-\frac{1}{28}x^3-\frac{1}{72}x^4-\frac{5}{704}x^5}$, &c.—— If the Chord ED be drawn, twice the Segment BDE will be nearly equal to $\frac{2}{3}\overline{ED+BD}\times\frac{4}{5}BE$. or biſſecting BE in F, and drawing DF; twice that Segment will be $=\frac{4DF+ED}{15}\times 4BE$ nearly.



41. If r be the Radius of a Circle and x the Diſtance of any given



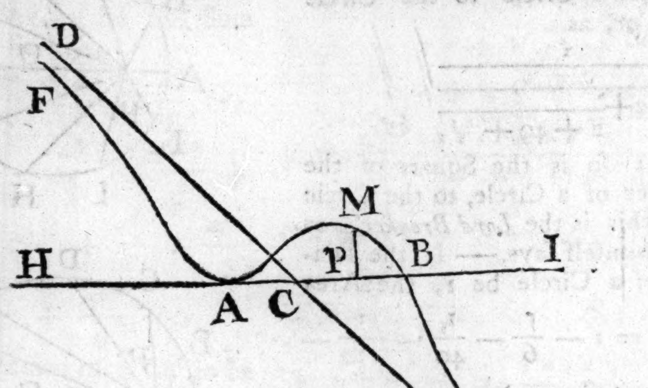


Point

Point P, in the Diameter from the Centre O, and m be any given Number; and if the Circumference be divided into as many equal Parts AB, BC, CD, *&c.* as there are Units in $2m$, and from the Point P to all the Points of Division be drawn the right Lines AP, BP, CP, DP, + *&c.* then will AP × CP × EP, *&c.* be $= r^m \pm x^m$, according as P falls within or without the Circle; and the Product of BP × DP × FP, *&c.* will be $= r^m + x^m$. This famous Theorem first appeared in Mr. *Cotes*'s *Harmonia Mensurarum*; but without a Demonstration.—— Dr. *Pemberton*, in a little Piece entitled *Epistola ad Amicum*, and Mr. *De Moivre* in his *Miscellan. Analytica*, have each demonstrated it.

42. Thus have I given a few of the most useful and elegant Properties of the Circle, extracted out of various Authors. Some of the Writers upon the Circle expresly or occasionally, are (1.) *Euclid*, in his *Elements*, lib. 3. (2.) *Apollonius*, in his *Conic Sections*, and *Tractatus de Locis planis*. (4.) *Archimedes*, in *Libello de Dimensione Circuli*, and his *Liber Assumptorum*. (5.) *Pappus*, in *Collectiones Mathemat.* (6.) *Gregory St. Vincent*, in his *Quadratura Circuli*. (7.) *Vincent Leotaudus*, in his *Amœnior Contemplatio Curvilineorum*. (8.) *Van Grafen von Herberstein*, in *Diatome Circulorum*. (9.) All Treatises of *Conic Sections*, (for a Circle is a Conic Section.) (10.) *Vieta*, in his Works. (11.) Mr. *Huygens*, in his *Inventa de Circuli Magnitudine*.

Circle of the higher Kind, an idle Word of *Wolfius*, and some others, signifying generally a Curve expressed by the Equation $y^m = a x^{m-1} - x^m$; which indeed will be an Oval when m is an even Number; but when m is an odd Number, the Curve will have two infinite Legs; as suppose $m = 3$, then the Curve FAMG expressed by the Equation $y^3 = ax^2 - x^3$, where AP, x, PM, y, and AB, a, will be one of Sir *Isaac Newton*'s defective Hyperbola's, being according to him the 37th Species, whose Asymptote is the right Line DE at half right Angles with the Abscis HI; and to call such a Curve a Circle, is making a wrong use of Words.



CIRCLES *of Altitude*. See *Almicanters*.

CIRCLES *of Declination on the Globe*, by some Writers, are the Meridians on which the Declination, or Distance from the Equator of any Planet or Star is accounted.

CIRCLE EQUANT, in the old Astronomy, is a Circle described on the Centre of the Equant; and the principal Use thereof is to find the Variation of the first Inequality.

CIRCLES *of Longitude on the Globe*, are great Circles, passing thro' a Star, and the Poles of the Ecliptic, where they determine the Star's Longitude, reckon'd from the Beginning of *Aries*; and upon them the Latitudes of the Stars are accounted.

CIRCLES *of Position*, are Circles passing thro' the common Intersections of the *Horizon* and *Meridian*, and thro' any Degree of the Ecliptic, or the Centre of any Star or other Point in the Heavens; and are used for finding out the Situation, or Position of any Star, &c.

CIRCULAR NUMBERS. These, by some, are such, whose Powers terminate in their Roots themselves; as 5 and 6, whose Powers do end in 5 and 6; the Square of 5 being 25, and of 6, 36, &c.

CIRCULAR VELOCITY, a Term in Astronomy; and signifies, that Velocity of any Planet or revolving Body, which is measured by the Arch of a Circle.

CIRCUMAMBIENT. See *Ambient*.

CIRCUMFERENCE, is the outermost bounding Line, or Lines of any plain Figure.

CIRCUMFERENTOR, an Instrument used in Surveying, being a large Box and Needle, fasten'd on to the middle of a Brass Index, with Sights at each end of the Index.

CIRCUMGYRATION, is the Motion of any Body about a Centre.

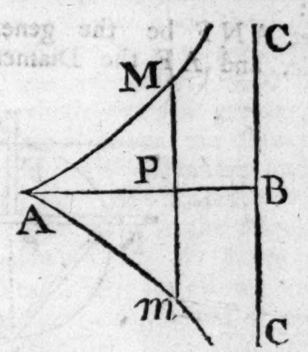
CIRCUM-POLAR STARS, are such Stars, that being pretty near to our North-Pole, do move round it; and in our Latitude never set, or go below the Horizon.

CIRCUMSCRIBED. A Figure, in Geometry, is said to be circumscribed, when either the Angles, Sides, or Planes of the circumscribed Figure touch all the Angles of the Figure that is inscribed.

CIRCUMSCRIBED HYPERBOLA, is one of Sir *Isaac Newton*'s Hyperbolas of the second Order that cuts its Asymptotes, and contains the Parts cut off within its own Space.

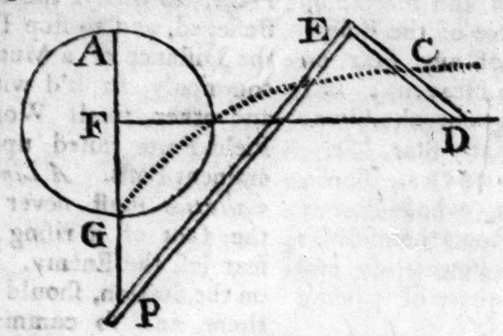
CIRCUMVALLATION, or the *Line of Circumvallation*, in Fortification, is a Trench, border'd with a Parapet round about the Besieger's Camp, within Cannon-shot of the Place, to hinder the Relief of the Besieged, and to stop Deserters. At the Distance of a Musket-shot it is commonly flank'd with Redoubts, and other small Works, or with Field-Forts raised upon the most eminent Posts. *A Line of Circumvallation* must never be drawn at the foot of a rising Ground, for fear lest the Enemy, having seized on the Station, should plant Cannon there, and so command the Line. This Line is usually about seven Foot deep, and twelve broad.

CISSOID, is a Curve of the second Order, as AM, Am, consisting



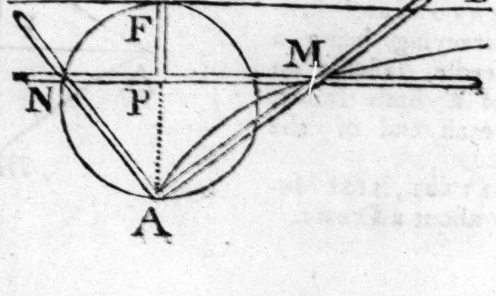
of

of two infinite Hyperbolic Legs AM, A*m*, having a right Line AB for a Diameter, and a right Line CC its Asymptote, and of such a nature that calling AB, *a*, the Abscifs AP, *x*, and the Correspondent Semi-Ordinate PM, or P*m*, *y*, it will be $yy \times \overline{a-x} = x^3$. This Name was given to the Curve by *Diocles* an ancient *Greek* Geometrician, being principally devised for finding two mean Proportionals between two given right Lines; but Sir *Isaac Newton* in his *Enumeratio Linearum tertii Ordinis*, reckons it amongst one of the defective Hyperbola's, being according to him the 42d Species. In his Appendix *de Æquationum Constructione Lineari*, at the End of his *Arithmetica Universalis*, he gives the following elegant Description of this Curve, and at the same time shews how to find two mean Proportionals, and the Roots of a Cubic Equation, without any previous Reduction by means thereof. Let AG be the Diameter, and F the Centre of the Circle belonging to the Cissoid; and from F draw FD, FP, at right Angles to each other, and let FP be = AG; then if the Square PED be so moved, that one Side EP thereof always passes through the Point P, and the End D of the other Side ED, slides along the right Line FD, the middle Point C of the Side ED, will describe one Leg GC of the Cissoid, and by continuing out FD on the other Side F, and turning the Square about by a like Operation, the other Leg may be described.



There is another way, which I thought upon to describe this Curve by a continued Motion; and it is thus:

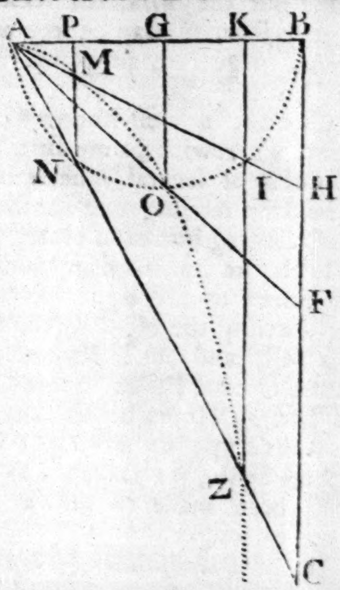
Let ANF be the generating Circle, and AF the Diameter at right Angles to the Asymptote FB. Take two Squares, a single one NAM, and a double one or T*ee* NPOPM, and fasten the Angle of the single Square in the Point A, so as to be moveable about the



same.

same. Thus if the Leg PO of the double Square be moved along AF, and the Intersection N of the Leg AN of the single Square, with the Leg NP of the double Square be moved along the Circumference ANF of the Circle; the Intersection M of the other Leg AM of the single Square, with the other Leg PM of the double Square, will describe the Leg AM of the Cissoid; and after the same manner the other Leg may be described.

This Curve may be described by Points after the following manner: Join the indefinite right Line BC at right Angles to AB, the Diameter of the Semi-circle AOB, and draw the right Lines AH, AF, AC, &c. then if you take AM = IH, AO = OF, ZC = AN, &c. the Points M, O, Z, &c. will form the Curve AMOZ of the Cissoid.



1. Draw the right Lines PM, KI, perpendicular to AB, then AK = PB and PN = IK.

2. The Lines AK, PN, AP, PM, as also AP, PN, AK, KL, are continual Proportionals.

3. Sir *Isaac Newton*, in his last Letter to Mr. *Leibnitz*, has shewn how to find a right Line equal to one of the Legs of this Curve, by means of the Hyperbola; but suppressed the Investigation, which however may be seen in his Fluxions.

4. The Cissoidal Space contained under the Diameter AB, the Asymptote BC, and the Curve AOZ, of the Cissoid, is the Triple of the generating Circle ANB.

Dr. *Wallis* treats of this Line in his Mathematical Works, *Vol.* I. pag. 545. and following.

Civil Day. See *Day*.

Civil Year, is the legal Year, or annual Account of Time, which every Government appoints to be used within its own Dominions; and begins with us the 25th Day of *March*.

Clepsydra, an Instrument of the Ancients, particularly the *Egyptians*, to measure Time with, by the running of Water out of one Vessel into another.

There were many kinds of them: But in all, the Water ran gently thro' a narrow Passage from one Vessel into another; and in the lower was a Piece of Cork, or light Wood, which, as the Vessel fill'd, rose up by Degrees, and so shew'd the Hour.

But in these Instruments there were two Inconveniencies: The first whereof was that the Air, according to its different Temperature, as to Heat, Cold, Density, &c. had an influence upon the Running of the Water, so as to make it measure Time unequally. And the second, which was yet greater, that the Water always ran slower out, according as its Quantity and Pressure in the Vessel abated.

Mr. *Varignon*, in the *Memoirs de l'Academie Royale des Sciences*, for the Year 1699, lays down a general geometrical Method of making *Clepsydra's*, or *Water-Clocks*, with any kind of Vessels, and with any given

given Orifices for the Water to run out of.

Vitruvius, in lib. 9. of his *Architecture*, treats of these Instruments; and *Pliny*, in chap. 60. lib. 7. says, that *Scipio Nasica* was the first who measured Time at *Rome* by *Clepsydra's*, or *Water-Clocks*.— *Gesnerus*, in his PANDECTES, pag. 91. gives several Contrivances of these Instruments.— There is *Solomon de Caus*, who treats of this Subject in his *Reasons of moving Forces*, &c. So also does Mr. *Ozanam*, in his *Mathematical Recreations*, wherein is a Treatise of Elementary Clocks, translated from the *Italian* of *Dominique Martinelli*. You have also a Treatise of Hour-Glasses, by *Arcangelo Maria Radi*, call'd *Nova Scienza di Horologi Polvere*.— See more, in the *Technica Curiosa* of *Gasper Schottus*; and Mr. *Amonton's Remarques & Experiences Physiques sur la Construction d'une nouvelle* Clepsydre, *exempte des défauts des autres*.

CLIFF, or *Cleff*, a Term in Music, signifying a certain Mark, from the Position whereof the proper Places of all other Notes, in a Piece of Music, are known. And there are four of them.

The first of these Cliffs is called *Faut-Cliff*, and belongs to the *Bass*; the *Cefaut-Cliff*, or *Tenor-Cliff*; the *Counter-Tenor*, or *Bemi-Cliff*: and and the *Treble* or *Gamut-Cliff*.

CLIMACTERICAL YEARS, are certain observable Years, being supposed to be attended with some great Mutation of Life, or Fortune. These are the seventh Year; the twenty-first, made up of three times seven; the forty-ninth, made up of seven times seven; the sixty-third, being nine times seven; and the eighty-first, which is nine times nine; which two last are called the *Grand Clymacterical Years*. *Aulus Gellius* says, this Piece of Stuff came from the *Chaldeans* first. And it is probable, that *Pythagoras* had it from them; who used to talk very much of the Efficacy of the Number Seven, being a Number he was extremely in love with.

CLIMATE, is a Part of the Superficies of the Earth, bounded by two Circles, parallel to the Equator, so that the longest Day in that Parallel, nearest to the Pole, exceeds the longest Day in that Parallel nearest to the Equator, some certain definite Part of Time, *viz.* half an Hour, till you come to Places situate nearly under the Arctic Circle; and a whole Hour, or even several Days, when you go beyond it.

The ancient *Greek* Geographers reckoned only seven Climates from the Equator, towards the North Pole; and denominated them from some noted Place, thro' which the middle Parallel of the Climate passed. But the Moderns reckon up twenty-four, as may be seen in *Varenius*, page 319, prop. 13. chap. 25. lib. 2.

CLOCK, a well-known Instrument, wherewith to measure Time, consisting of several Wheels of various Sizes moving one another, by Teeth fitting into each other, which Wheels are continued in Motion by the Force of a Weight, or Spring, and shewing the Hour by the Sound of a Bell, and an Index moving about a circular Plate. Some Clocks go but 24 Hours before they must be wound up: Others eight Days: Others again, 32 Days; and some have been made to go a whole Year, or longer.

In the *Disquisitiones Monasticæ* of *Benedictus Haëften*, published in the Year 1644, he says, that Clocks were invented by *Silvester* the IVth. a Monk of his Order, about the Year 998, as *Ditmarus* and *Bozius* have shewn; for before that time, they had nothing but Sun-Dials, and Clepsydra's to tell the Hour.—*Conrarde*

rarde Gesner, in his *Epitome*, pag. 604, says, that *Richard Wallingford*, an *English* Abbot of *St. Albans*, who flourished in the Year 1326, made a wonderful Clock by a most excellent Art, the like of which could not be produced by all *Europe*.— *Moreri* under the Word *Horologe du Palais*, says, that *Charles* the Fifth, call'd the wise King of *France*, order'd at *Paris* the first great Clock to be made by *Henry de Vic*, which he sent for from *Germany*, and set it up upon the Tower of his Palace; and this was in the Year 1372.—— *John Froissart*, in *chap.* 28. vol. 2. of his *Histoire & Chronique*, says, the Duke of *Bourgogne* had a Clock which sounded the Hour, taken away from the City of *Courtray*, in the Year 1382. And *William Paradin*, in his *Annales de Bourgogne*, says the same thing.

There are several Treatises upon Clocks; the principal of which are, *Hieronymi Cardani de Varietate Rerum Libri* XVII.— *Conrandi Dasypodii Descriptio Horologii Astronomici Argentinensis in summo Templi erecti*. —*Guidonis Pancirolli antiqua deperdita & nova reperta*.— *L'Usage du Cardan, ou de l'Horologe Physique universelle, par Galilée Mathematicien du Duc de Florence*.— Mr. *Oughtred*'s *Opuscula Mathematica*.— Mr. *Huygens*'s *Horologium Oscillatorium*.—— *Pendule Perpetuelle, par l'Abbe de Hautefeuille*.— *J. J. Becheri Theoria & Experientia de nova Temporis dimentiendi Ratione & Horologiorum Constructione*.— *Clark*'s *Oughtredus explicatus, ubi de Constructione Horologiorum*.— Horological Disquisitions.— Mr. *Huygens*'s posthumous Works.— Mr. *Sully*'s *Regle Artificielle du Temps*, &c.— Mr *Serviere*'s *Recueil d'Ouvrages Curieux*.— Mr. *Durham*'s Artificial Clock-Maker. — Mr. *Camus*'s *Traite des Forces Mouvantes*.—Mr. *Alexandre*'s *Traité Général des Horologies*.

Close, in Music. See *Cadence*.

Clouds, are a Congeries of Waters, drawn up from the Sea and Land into Vapours; which when they are very nearly placed to one another, appear dense and thick; but when they are more remote, are clear and bright, and sometimes almost transparent.

Clouds swim in the Air at but a small distance from the Surface of the Earth: For those, who have taken their Altitudes, do affirm, that they do not exceed one Mile in Height, and many of them not above half a Mile.

Clouts, are thin Plates of Iron, nail'd on that Part of the Axle-tree of a *Gun-Carriage* which comes thro' the *Nave*, through which the *Lins-Pin* goes.

Coacervate Vacuum. See *Vacuum*.

Coalition, is the gathering together, and uniting into sensible Masses, the minute Corpuscles that compose any concrete or natural Body; and a *Coalescency* is commonly taken for the same.

Coasting, is that Part of Navigation where the Places assigned are not far distant, so that a Ship may sail in sight of Land, or within Soundings, between them.

Co-Efficient *of any generating Term in Fluxions*, is the Quantity arising by the Division of that Term by the generated Quantity.

Co-Efficients, in Algebra, are such Numbers, or given Quantities, that are put before Letters, or unknown Quantities, into which Letters they are supposed to be multiplied, and so do make a Rectangle or Product with the Letters; as here, $3a$, or bx, or Cxx; where 3 is the Co-Efficient of $3a$; b, of bx, and C of Cxx.

In a Quadratic Equation the Co-Efficient is, according to its Sign, either the Sum or Difference of its two Roots.

In

In any Equation the Co-Efficient of the second Term is always equal to the Sum of all the Roots, keeping their proper Signs.

The Co-Efficient of the third Term, is the Sum of all the Rectangles arising by the Multiplication of every two of the Roots, how many ways soever those Combinations of two's can be had; as three times in a Cubic, six in a Biquadratic Equation, &c.

The Co-Efficient of the fourth Term, is the Aggregate of all the Solids made by the continual Multiplication of every three of the Roots, how often soever such a Ternary can be had; and so on, *ad infinitum*.

COFFER, in Fortification, is a hollow Lodgment a-cross a dry Moat, from six to seven Foot deep, and from sixteen to eighteen broad, the upper Part being made of Pieces of Timber, raised two Foot above the Level of that Moat; which little Elevation has Hurdles laden with Earth for its Covering, and serves as a Parapet with Embrasures.

The Besieged generally make use of these Coffers to repulse the Besiegers, when they endeavour to pass the Ditch. And they differ only in Length from the Caponniers, which are also something less in Breadth.

COLD, is one of the primary Qualities of Body, and is no more than the arriving of the minute and insensible Parts of any Body at such a State, as that they are more slowly or faintly agitated than those of our Fingers, or other Organs of Feeling; for from this Effect we say a Body is cold.

COLLISION, is the striking of one hard Body against another.

COLOUR, is that Quality of a natural Body, whereby it is disposed to modify Light falling upon it, and striking upon the Organ of Sight, so as to produce that Sensation we call *Colour*.

Sir *Isaac Newton* was the first that, from Experiments on Prisms, found there was a great Deformity in the Rays of Light; and from thence found, that Colours are not Qualifications of Light, derived from Refractions or Reflections of natural Bodies, but original and connate Properties, which in divers Rays are different; some Rays being disposed to exhibit a red Colour, and no other; some a green, and no other; and so of the rest. Nor are there only Rays proper and particular to the more eminent Colours, but even to all their intermediate Gradations.

The least refrangible Rays are all disposed to exhibit a red Colour; and the most refrangible ones, are those that express a Violet Colour.

There are two sorts of Colours; the one original and simple, and the other compounded of these. The original and primary Colours are red, yellow, green, blue, and a violet purple, together with orange, indigo, and an indefinitive Number of intermediate Gradations.

The same Colours in *Specie*, with these primary ones, may be also produced by Composition; for a Mixture of yellow and blue makes green; of red and yellow makes orange; of orange and yellowish green makes yellow. And generally, if any two Colours be mixed, which, in the Series of those generated by the Prism, are not too far distant from one another, they, by their mutual Alloy, compound that Colour which in the said Series appears in the Midway between them: But those that are situated at too great a distance, do not do so. Orange and Indigo produce not the inter-

intermediate green, nor ſcarlet and green the intermediate yellow.

Whiteneſs is the uſual Colour of Light, Light being a confuſed Aggregate of Rays, endued with all ſorts of Colours, as they are promiſcuouſly darted from the various Parts of luminous Bodies; and of ſuch a confuſed Aggregate is generated Whiteneſs, if there be a due Proportion of the Ingredients.

The Colours of all natural Bodies have no other Origin than this, *viz.* That they are variouſly qualified to reflect one ſort of Light in greater plenty than another; as Sir *Iſaac Newton* has ſhewn in the *Philoſophical Tranſactions.*

The Senſations of different Colours ſeem to ariſe from hence, That ſeveral ſorts of Rays do make Vibrations of ſeveral Bigneſſes, which, according to their Magnitudes, do excite Senſations of different Colours; much after the ſame manner that the Vibrations of the Air, according to their ſeveral Bigneſſes, do excite Senſations of different Sounds.

And it is probable that the Harmony and Diſcord of Colours (for ſome Colours, as of Gold, Yellow, and Indigo, are agreeable to the Eyes, and others not) ariſe from the Proportions of theſe Vibrations propagated through the Fibres of the Optic Nerves into the Brain, juſt as the Harmony and Diſcords of Sounds ariſe from the Vibrations of the Air.

Column, is a kind of a round Pillar, compoſed of a Baſe, a *Fuſt*, or *Shaft*, and a *Capital*, and ſerves to ſupport the *Entablement*.

Columns are different, according to the different Orders, being capable of a great Number of Variations, with regard to Matter, Conſtruction, Form, Diſpoſition, and Uſe.

The *Tuſcan*, being the ſhorteſt and moſt ſimple, according to ſomes is ſeven Models long, comprehending its Baſe and Capital, and diminiſh'd a fourth Part of its Diameter.

The *Dorick*, ſeven and a half, or eight Diameters long, and its Baſe and Capital are ſomewhat more beautified with Mouldings.

The *Ionick* Column, nine Diameters long, and has its Capital ſet off with Voluta's, or curled Scrolls, differing in that reſpect from others, as well as its Baſe, which is peculiar to it.

The *Corinthian*, the richeſt of all, being ten Diameters in Length, has two Rows of Leaves for the Ornament of its Capitals, with Stalks or Stems, from whence ſhoot forth ſmall Voluta's.

The *Compoſite* Column, is alſo ten Diameters long, and its Capital is made like that of the *Corinthian.*

Colures, are two great Circles, imagin'd to paſs through the Poles of the World, one of them through the Equinoctial Points *Aries* and *Libra*, and the other through the Solſtitial Points, *Cancer* and *Capricorn*; they being called the Equinoctial and Solſtitial Colures.

Coma-Berenices, a Northern Conſtellation of fix'd Stars.

Combination *of Quantities*, is the manner of finding how many different ways they may be varied, or taken one and one, two and two, three and three, &c. as the Number of Combinations of three Quantities *a b c*, two and two are three, *viz.* *ab*, *ac*, *bc*. If three Quantities are to be combin'd, and their Number is only three, as *a b c*, then the Number of Combinations will be only one, *viz.* *a b c*; and if there are four Quantities *a b c d*, and three to be taken, then the Combinations will be four, *viz.* *a b c*, *a b d*, *b c d*, *a c d*; and if the

M Number

Number of Quantities to be combin'd be called q, and u be the Number of them to be taken, then the Number of Combinations will be $\frac{q-u+1}{1} \times \frac{q-u+2}{2} \times \frac{q-u+3}{3} \times \frac{q-u+4}{4} \times \frac{q-u+5}{5}$, &c. For Example: Let the Number of the Quantities to be combin'd be 6, and let 4 be the Number of them taken; then the Number of the Combinations will be

$$\frac{6-4+1}{1} \times \frac{6-4+2}{2} \times \frac{6-4+3}{3} \times \frac{6-4+4}{4} = \frac{3}{1} \times \frac{4}{2} \times \frac{5}{3} \times \frac{6}{4} = 15.$$

The Number of all the possible Combinations beginning from the Combinations of every two will be $2^q - q - 1$; as when the Number of Quantities be 5, then the Number of the possible Combinations will be $2^5 - 6 = 26$.

If u represents any Number of Quantities, then will $\frac{u^{u+1} - u}{u-1}$ express the possible Number of all the Variations; as if $u = 4$, then $\frac{4^5 - 4}{4-1} = \frac{1020}{3} = 340$.

Combust, a Term in Astronomy. When a Planet is not above eight Degrees and thirty Minutes distant from the Sun, either before or after him, he is said then to be combust, or in Combustion.

Comets, are Stars, most of which have Tails, suddenly arising in the Heavens, and appearing for some time, do afterwards again disappear; and all the time that they are seen, they, like the Planets, move every Day some certain Length in their proper Orbits.

Aristotle, and his Followers, supposed that Comets were only Meteors or Exhalations, set on fire in the highest Region of the Air, below the Moon. And this Opinion had so far prevailed, that no body thought it worth while to write concerning the uncertain Motions of a Vapour or Exhalation; and so nothing certain about the Motions of Comets can be found transmitted from them to us.

But *Seneca*, the Philosopher, from the Consideration of the Phænomena of two remarkable Comets of his Time, made no scruple to place them among the Celestial Bodies, and believed them to be Stars of equal Duration with the World, tho' he could not tell the Laws of their Motion; but prophesied that After-Ages would find out in what Parts of the Heavens the Comets wander'd, what and how great they were.

Tycho Brahe, in the Year 1577, first observed a Comet, that then appeared to have no *Diurnal Parallax*, and consequently was not only no Aerial Vapour, but also much higher than the Moon. And afterwards *Kepler* found that the Comets moved freely thro' the Orbits of the Planets, with Motions very little different from right-lin'd ones. And *Hevelius* embracing the same right-lin'd Motion of the Comets, observ'd many of them; but complain'd, that his Calculations did not agree to the Matters of Fact in the Heavens; and found that the Path of a Comet was bent into a Curve-Line towards the Sun.

But from the accurate Observations of the great Comet of the Year 1680, Sir *Isaac Newton* shews, in his *Principia*, that Comets move in Conic Sections, having their Foci in the Centre of the Sun, and by Rays drawn to the Sun, do describe Area's proportional to the Times; and so, if Comets return in their Orbits,

Orbits, the Orbits are Ellipses, and the periodic Times are to the periodic Times of the Planets in the sesquiplicate Ratio of the principal Axes. But the Orbits of Comets are so near to Parabola's, that Parabola's may be taken instead of them, without any sensible Error.

The Planes of the Orbits of Comets are always inclined to the Plane of the Ecliptic; and some move from East to West, some from West to East, some from North to South, and some from South to North.

The Bodies of Comets, according to Sir *Isaac Newton*, are solid, compact, fix'd, and durable, like the Planets, and shine by the Light of the Sun-Beams reflected from them: And the Tail of a Comet is only a long and very thin Smoak, or Train of Vapours, which the Head of the Comet emits from it, by being vastly heated by the Sun; and always appears on that side of the Comet opposite to the Sun.

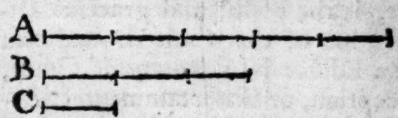
John Regiomontanus was the first who has shewn how to find the Magnitude of Comets, their Distance from the Earth, and their true Place in the Heavens; his 16 Problems *de Cometæ Magnitudine, Longitudine, ac Loco*, are to be found in an ancient Book published in the Year 1544, with the Title of *Scripta Joannis Regiomontani*.

Writings about Comets, are *Tycho Brahe*, his *Progymnasmata Astronomiæ Instauratæ*.— *Kepler*, of the Comet (in *High-Dutch*) in the Year 1607. and *de Cometis Libelli tres*. —*Hevelius*'s *Prodromus Cometicus*, containing an History of the Comet of the Year 1664. Also his *Cometographia*.— Dr. *Hook*, his posthumous Works.— Mr. *Cassini*'s little Tract of Comets — Mr. *Sturmius*'s *Dissertatio de Cometarum Natura*.— Sir *Isaac Newton*, his *Principia Philosophiæ Naturalis Mathemat.* lib. 3.— Dr. *Halley*, his *Synopsis Cometica*, in the *Philosophical Transactions*, n. 218.

Comma, a Term in Music, being the ninth Part of a Tone, or the Interval whereby a Semi-Tone, or a perfect one exceeds the imperfect. This is used only in the Theory of Music, to shew the exact Proportion between Concords.

Commanding Ground, in Fortification, is such as overlooks any Post, or strong Place, and is of three sorts: First, a Front *commanding Ground*, which is an Height opposite to the Face of the Post, which plays upon its Front. Secondly, a reverse *commanding Ground*, which is an Eminence that can play upon the Back of any Place, or Post. Thirdly, an *Enfilade Commanding Ground*, which is an high Place, that can, with its Shot, scour all the Length of a straight Line.

Commensurable Magnitudes, are such as are measur'd by one and the same common Measure; as, if the Magnitudes A, B,



the one 5, and the other 3, be measur'd exactly by the Magnitude C, supposed to be 1; then the Magnitudes A and B are called *Commensurable*.

Commensurable Numbers, whether Integers or Fractions, are such as have some other Number which will measure or divide them without any Remainder: Thus, 4 and 6, or $\frac{8}{12}$ and $\frac{3}{4}$ are commensurable.

Commensurable *in Power*. Right Lines, by *Euclid*, are said to be commensurable in Power, when their Squares are measured by one and the same Space or Superficies.

Commensurable Surds, are ſuch Surds, that being reduced to their leaſt Terms, become true figurative Quantities of their Kind; and are therefore as a rational Quantity to a rational one.

Common Axis, in Optics. See *Axis*.

Common Divisor, is that Number that exactly divides any two other Numbers, without a Remainder.

Common Measure, is ſuch a Number that exactly meaſures two or more Numbers without a Remainder.

Common Measure (*greateſt*,) of two or more Numbers, is the greateſt Number that can meaſure them; as, 4 is the greateſt common Meaſure of 8 and 12.

Common Ray, in Optics, is a Right Line drawn from the Point of Concurrence of the two optical Axes, thro' the Middle of the Right Line, paſſing thro' the Centre of the Pupil of the Eye.

Compartition, in Architecture, is the uſeful and graceful Diſtribution of the whole Ground-plat of an Edifice into Rooms of Office, Reception, or Entertainment, *&c.*

Compartment, in Architecture, is a peculiar Square or other figur'd Space, (for an Inſcription, *&c.*) mark'd out in ſome ornamental Part of a Building.

Compass, in Navigation, is a Circle, or Chard of Paſtboard, divided into thirty-two equal Parts, called *Rhumbs*, or *Points*, repreſenting the thirty-two Winds, with the initial Letters of their Names ſet to them, having a touched Needle or Wire fix'd to it underneath, and in its Centre a Braſs Cell, or Conical Cavity, by means of which it hangs on an erect Pin, ſet up in the Centre of another ſuch Chard, fitted in a Wooden or Braſs Box, with Jambols, or Braſs Hoops; ſo that during the Motion of the Ship, the Chards may be nearly Horizontal, and the Flower-de-Luce of the upper Chard will always point towards the North.

This Inſtrument, tho' it be ſubject to Accidents, is of great uſe in *Navigation*; and all the conſiderable Diſcoveries of Countries are owing to the ſame.

The Invention of it, by ſome, is attributed to one *John Goia*, of *Amalphi*, in *Campania*, in the Kingdom of *Naples*; who made the Chard thereof to conſiſt only of eight Points, *viz.* the four Cardinal, and four Collateral ones. Others ſay it was the Invention of the People of *China*. And *Gilbert*, in *Libro de Magnete*, affirms, That *Paulus Venetus* brought it firſt into *Italy* in the Year 1260, having learned it from the *Chineſe*. And *Ludi Vertomanus* affirms, That when he was in the *Eaſt-Indies*, about the Year 1500, he ſaw a Pilot of a Ship direct his Courſe by a Compaſs, faſten'd and framed as thoſe that now are commonly uſed.

And Mr. *Barlow*, in his *Navigator's Supply*, *Anno* 1597, ſays, That in a perſonal Conference with two *Eaſt-Indians*, they affirmed, that inſtead of our Compaſs, they uſe a Magnetical Needle of ſix Inches, and longer, upon a Pin in a Diſh of white China Earth, filled with Water; in the bottom whereof they have two Croſs-Lines for the principal Winds, the reſt of their Diviſions being left to the Skill of their Pilots. Alſo, in the ſame Book, he ſays, That the *Portugueſe*, in their firſt Diſcovery of the *Eaſt-Indies*, got a Pilot of *Mahinde*, that brought them from thence in thirty-three Days, within ſight of *Calicut*.

Compass Dials, are ſmall Horizontal Dials, fitted in Braſs or Silver Boxes for the Pocket, and are

are set North and South, by means of a Compass, or touched Needle belonging to them.

COMPASSES *of Proportion*, or *Proportional Compasses*, are such that have two Legs, but four Points, which, when opened, are like a Cross, not having the Joint at the End of the Legs, as common Compasses: And some of these have fixed Joints, others moveable ones; upon the Legs of the latter of which are drawn the Lines of Chords, Sines, Tangents, *&c.* as on the Sector.

Their Use is to divide Right Lines, and Circles into equal Parts, or to perform other Operations of the Sector at one opening of them.

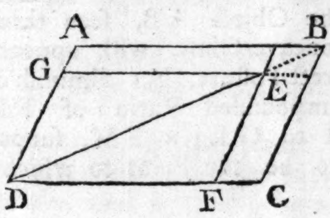
COMPLEMENT *of any Arch or Angle, to any other Arch or Angle*, (as of ninety Degrees, an hundred and eighty Degrees, *&c.*) is the Arch or Angle, which, together with that Arch or Angle, makes up ninety Degrees, or a hundred and eighty Degrees, *&c.*

COMPLEMENT *of the Course* in Navigation, is the Number of Points the Course wants of ninety Degrees, or eight Points, that is, of one fourth of the Compass.

COMPLEMENT *of the Courtain*, in Fortification, is that Part of the Courtain which (being wanted) is the Demi-Gorge.

COMPLEMENT *of the Line of Defence*, is the Remainder of the Line of Defence after the Angle of the Flank is taken away.

COMPLEMENTS *in a Parallelogram*, are the two small Parallelograms AGE, FCE, made by drawing two right Lines GE, FE, through the Point E, in the Diagonal; parallel to the Sides AB, BC, of any Parallelogram ABCD.



In every Parallelogram these Complements are equal.

COMPOSITE NUMBERS, are such, that some Number besides Unity can measure; as 12, which is measur'd by 2, 3, 4, and 6.

COMPOSITE NUMBERS, between themselves, are such that have some common Measure besides Unity; as 12 and 15, which may be both measur'd by 3.

COMPOSITE *Order*, is the fifth Order of Architecture; and is so called, because its Capital is composed of two Rows of Leaves proper to the *Corinthian* Order, and the Voluta's of the *Ionic*. This Order is sometimes called the *Italic* or *Roman*, as having been first invented by that People. Its Column is ten Diameters in Height, and there are always Dentiles or simple Modillions to its *Cornice*.

COMPOSITION, is the reverse of the Analytic Method, or of Resolution. It proceeds upon Principles self-evident, on Definitions, Postulatums, and Axioms, and a previously demonstrated Series of Propositions, step by step, till it gives a clear Knowledge of the Thing demonstrated. This is what they call the Synthetical Method, and is used by *Euclid*, *Apollonius*, and most of the Ancients.

COMPOSITION *of Proportion.* If there be two Ratio's, and it shall be as the Antecedent of the first Ratio to its Consequent, so is the Antecedent of another to its Consequent. Then, by Composition of Proportion, as the Sum of the Antecedent and Consequent of the first Ratio, to the Antecedent or Consequent of the first, so is the Sum of the Antecedent

dent and Consequent of the second, to the Antecedent or Consequent of the second: As, if A : B :: C : D, then, by Composition, A + B : A (B) :: C + D : C (D).

COMPOUND *Interest*, is that Part of it that treats of the Money produced from any Principal, and its Interest put together, as the Interest of that Principal becomes due. That is, finding the new Principal that is still created by the Increase of the growing Money at every Payment, or rather at the Times when the Payments become due, is called *Compound Interest*, or *Interest upon Interest*.

If R be the Amount for one Pound of one Year, then $\overline{R}^2$ will be the Amount for two Years, $\overline{R}^3$ for three Years, $\overline{R}^4$ for four Years, *&c.*

As 1 *l.* is to its Amount for any given time, so is any proposed Principal or Sum to its Amount for the same time.

COMPOUND MOTION, is that which is produced by several Forces conspiring together; and Forces are said to conspire, when the Direction of the one is not contrary to the Direction of the other; as when the Radius of a Circle moves about the Centre, and at the same time a Point be conceived to go forwards along it.

Whence every curv'd-lin'd Motion is a Compound Motion.

COMPOUND QUANTITIES, in Algebra, are such as are connected together by the Signs + and —, and are expressed by the same Letters more than once, or else by the same Letters unequally repeated; as, $a+b-c$, and $bb-b$, are Compound Quantities.

COMPOUND RATIO. The Ratio that the Product of the Antecedents of two or more Ratio's has to the Product of their Consequents, is called a *Compound Ratio*: So 6 to 72 is in a Ratio compounded of 2 to 6, and 3 to 12.

The Exponent of a compound Ratio is equal to the Product that the Exponents of simple Ratio's produce.

As if m be the Exponent of the Ratio $\frac{A}{B}$, and n of $\frac{C}{D}$; then will mn be the Exponent of $\frac{AC}{BD}$, or of the Ratio compounded of $\frac{A}{B}$ and $\frac{C}{D}$.

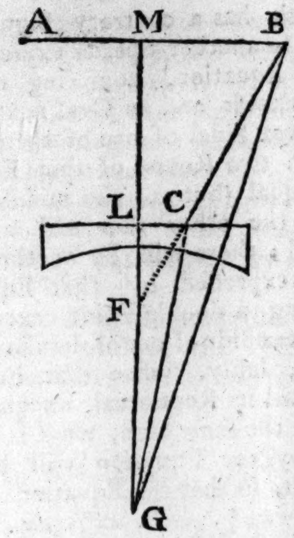
If there are never so many Quantities, A, B, C, D, E, F, *&c.* the Ratio of the first A to the last F, is compounded of the Ratio's of the Quantities being between the Extremes, *viz.* $\frac{A}{B}$, $\frac{B}{C}$, $\frac{C}{D}$, $\frac{D}{E}$, $\frac{E}{F}$, *&c.*

COMPRESSION, is the squeezing of a Mass of Matter into a lesser Bulk.

CONCAVE, or *Concavity*. This signifies the hollowness of any thing.

CONCAVE-GLASS, or *Lens*, is one that is flat on one side, and ground hollow on the other; but usually spherical. This, by some, is called a *Plano-Concave*, and if the Glass be Concave on both sides, it is called a *Double-Concave*.

The Object AB, seen through a Concave-Glass, will appear in an erect Posture, but diminish'd in a compounded Ratio of FL × GM to GL × FM, supposing F to be the Point to which the Ray



Ray BC tends unrefracted, and G the Eye.

The Rays of the Sun, in their Paſſage through a Concave-Glaſs, are weakened after the Refraction; and ſo the Effect of Concave-Glaſſes is contrary to that of Convex ones.

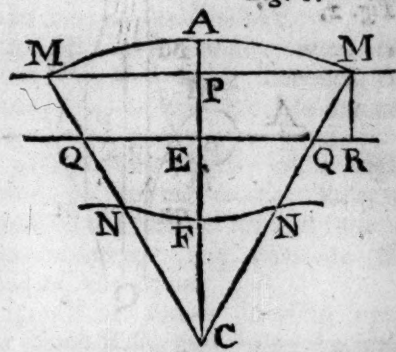
The confuſed Appearance of a Point through any Concave-Glaſs, proceeds from the too great Divergency of thoſe Rays that fall on the Eye; and ſo becauſe the more remote the Eye is from the Glaſs, the leſs will the Rays diverge; therefore, the further the Eye is from a Concave-Glaſs, the more diſtinct will the Appearance of any Object through it be, tho' it will be more faint.

The apparent Place of Objects, ſeen through Concave-Glaſſes, is always brought nearer to the Eye; and this is the Reaſon why they help ſhort-ſighted Perſons, or ſuch as can ſee nigh Objects only diſtinctly.

Concentric Figures, are ſuch as have the ſame common Centre.

Conchoid, is the Name of a Curve given to it by its Inventor *Nicomedes*, and is thus generated;

Fig. 1.



Draw the right Line QQ, and AC perpendicular to it in the Point E, and from the Point C draw many right Lines, CM cutting the right Line QQ in Q, and make QM = QN, AE = EF, *viz.* equal to an invariable Line: Then the Curve, wherein are the Points M, is called the firſt Conchoid; and the other, wherein are the Points N, the ſecond; the right Line QQ being the Directrix, and the Point C the Pole. And from hence it will be very eaſy to make an Inſtrument to deſcribe the Conchoid.

The Line QQ is an Aſymptote to both the Curves, which have Points of contrary Flexion.

If OM = AE = a EC = b, MR = EP = x, ER = PM = y; then will $a^2 b^2 - 2a^2 bx + a^2 x^2 = b^2 x^2 - 2bx^3 + x^4 + x^2 y^2$, expreſs the Nature of the ſecond Conchoid; and $x^4 + 2bx^3 + y^2 x^2 + b^2 x^2 = a^2 b^2 + 2a^2 bx + a^2 x^2$, the Nature of the firſt; and ſo both theſe Curves are of the third kind.

The firſt and ſecond Conchoid do in reality make but one Curve of the third Order, having four infinite Legs and but one Aſymptote between them; and of theſe there are three different Species expreſſed by the Equation, $xxyy = -ax^4 . bx^3 . cx^2 . dx . e$. where a, b, c, d, e, are invariable Quantities, the Abſciſs AP is x, and the Correſpondent Semi-ordinate PM, or

Fig. 2.

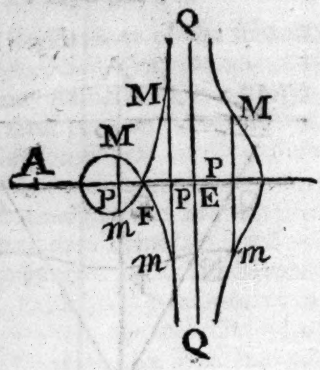
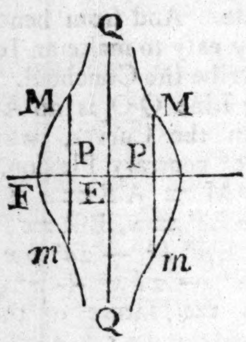


Fig. 3.

Fig. 4.



P*m*, *y*: For when the Equation $o = -ax^4 \,.\, bx^3 \,.\, cx^2 \,.\, dx \,.\, e$. has four real Roots, and the two middle ones be equal, the Curve will have a Node, as at *Fig*. 2. when three Roots of that Equation be equal, the Curve will have a triple Point, as F, in *Fig*. 3. and when two of the Roots are imaginary, the Curve at *Fig*. 4. will have only four infinite Legs. Moreover, when that Equation has three real unequal Roots with the ſame Sign, and the fourth has a contrary Sign, there will be another Species expreſſed by that Equation, conſiſting of two Conchoids and an Oval next to the Convex Sides of one of them; and when two Roots of that Equation be equal (but not the middle ones) and the other two real and unequal; there will be another Species expreſſed by that Equation, having a double Point next to the Convex Side of one of the Conchoids. And, laſtly, when that Equation has all its Roots real, unequal, and with the ſame Sign, what is expreſſed by the Equation will be two Ovals, ſo that the Equation $xxyy = -ax^4 \,.\, bx^3 \,.\, cx^2 \,.\, dx \,.\, e$. expreſſes ſix different Species of Curves. The firſt three of which will be deſcribed by what has been ſaid above; for if in the firſt *Fig*. the Line EF be taken greater than EC; the Conchoid of *Fig*. 2. will be had. If EF be = EC, that of *Fig*. 3. will be had; and when EF is leſs than EC, that of *Fig*. 1. or *Fig*. 4. will be had.

Sir *Iſaac Newton*, in the latter Part of his Algebra, tells us, That this Curve was uſed by *Archimedes* and other Ancients in the Conſtruction of ſolid Problems; and he himſelf prefers it before other Curves, or even the Conic Sections in the Conſtruction of Cubic and Biquadratic Equations, on account of its Simplicity and eaſy Deſcription, ſhewing therein the manner of their Conſtruction by help of it.

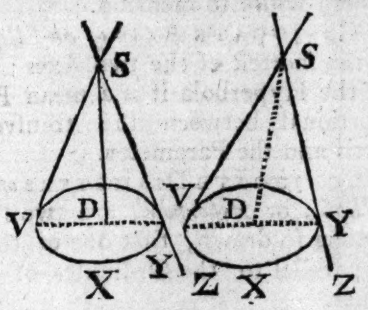
Concrete Numbers, are thoſe that are applied to expreſs or denote any particular Subject; as 3 Men, 2 Pounds, &c. Whereas, if nothing be connected with the Number, it is taken abſtractly or univerſally; as 4 ſignifies only an Aggregate of four Units, be they Men, Pounds, or what you pleaſe.

Concurring, or Congruent Figures, in Geometry, are ſuch, as

as being exactly laid upon one another, will exactly meet, and cover one another; and therefore it is a received Axiom, that plane Figures, exactly covering one another, are equal among themselves.

CONDENSATION, is when any Mass of Matter is thrust into a less Bulk than it was before, by means of Cold.

CONE. If the immoveable Point S be taken without the Plane, in which the Circle VXY is describ'd;



and if the indefinite right Line S Z, drawn through that Point, moves quite round the Circumference of that Circle, then that Line will generate a Superficies, and the Solid contain'd under the Base, or Circle VXY; and that Part of the Superficies between the Base and the Vertex, or Point S, is called a Cone; and if the Line S D, or Axis be at right Angles to the Plane of the Base, the Cone is called a right one; but if it be oblique, as in the second Figure, the Cone is called an oblique or scalene one.

Euclid, in his Eleventh Book, gives a Definition of a Cone that is not general, it being only of a right-angled Cone; for he says a Cone is produced by the Revolution of the Plane of a right-angled Triangle, about the perpendicular Leg remaining at rest.

1. Every Cone is one third Part of the Cylinder, having the same Base and Altitude; and so the Solidity of any Cone is equal to the Area of its Base, multiplied into one third Part of its Altitude.

2. All Cones standing upon the same Base, and being between the same Parallels, are equal to one another.

3. The Superficies of a right Cone, not taking in the Base, is equal to a Triangle, whose Base is the Periphery, and Altitude the Side of the Cone.

4. Of all Cones standing upon the same Base, and being between the same Parallels, (that is, having the same Altitude,) the Superficies of that which is the most oblique, is the greatest, and so the Superficies of the right Cone is the least; but the Proportion of the Superficies of an oblique Cone to that of a right one, or which is all one, the Comparison thereof to a Circle, or the Conic Sections, has not yet been determined.

Dr. *Barrow*, in his Geometrical Lectures, was the first who has shewn how to find a plane Curve Superficies equal to the Surface of an oblique Cone, which plane Superficies will be bounded by a Curve of the third Order; so that the Surface of an oblique Cone cannot be found, but by the Quadrature of a Space contained under a Curve of the third Order, and right Lines: for if the Altitude of the Cone be c, the Distance from the Centre of the Base to the Point in its Plane, upon which the Perpendicular falls be b, and any Abscis of the Base beginning at the Centre be call'd $\dot{x}$. and $a^4 + aacc$ be $= d^4$; the Fluxion of the Part of the Surface of the oblique Cone will be $= \frac{\dot{x}}{2a}$

$$\frac{\sqrt{bbxx - 2aabx + d^4}}{aa - xx}.$$ And

it is impossible to compare the Fluent of this with any of the Conic Sections. It may indeed be compar'd to

to Part of the Superficies of a right Cylinder, (whose Base is the Base of the Cone) made by cutting the Cylinder thro' by the Periphery of an Hyperbola moving parallel to itself, and at a given Distance from the Base of the Cylinder; the Semi-transverse Axis of which Hyperbola is $= \sqrt{\frac{d4}{aa} - aa}$, and the Semi-conjugate $= \frac{b}{aa}\sqrt{-a^4 + d^4}$.

5. The Centre of Gravity of a Cone is three fourths of the Axis distant from the Vertex.

Cone *of Rays*, in Optics, are all the Rays that fall from any Point of an Object upon the Surface of any Glass, having its Vertex in that Point, and the Glass for its Base.

Confused Vision. See *Vision*.

Conge, a Term in Architecture. See *Apophygee*.

Congruity *of Geometrical Figures*. See *Concurring*.

Conic Sections, are Curves made by cutting a Cone by a Plane, and leaving out the Circle and Triangle; are three in Number, *viz.* the Ellipsis, Hyperbola, and Parabola.

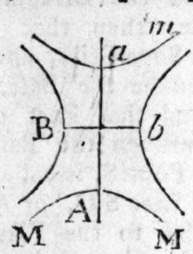
These Curves being all those of the second Kind, or Order, are of vast use in Mathematics. See more of them under the words Ellipsis, Hyperbola, and Parabola.

The most ancient Treatise upon *Conic Sections*, is, that of *Apollonius Pergæus*, containing eight Books; the four first of which have been oftentimes publish'd. But Dr. *Halley*'s Edition has the whole eight. *Pappus*, in *lib.* 7. *Collect. Mathemat.* says *Euclid* wrote four Books of Conics, which *Apollonius* afterwards stole and published as his own, with four more Books added to them.—Amongst the Moderns, there is *Mydorgius de Sectionibus Conicis.*—*Grigory St. Vincent*'s *Quadratura Circuli & Sectionum Coni* 10 *Libris comprehensa.*—*De la Hire*'s *Opus de Sectionibus Conicis.*—*De Witt*'s *Elementa Curvarum.*— Dr. *Wallis*'s Conic Sections.—*De l'Hospital*'s Analytical Treatise of Conic Sections, and their Use.—*Milnes*'s *Elementa Sectionum Conicarum nova Methodo demonstrata.*—Mr. *Simpson*'s Conic Sections.—Mr. *Muller*'s Conic Sections; and many others scarcely worth while to mention.

Conjugate Axis *of an Ellipsis*, is the shortest of the two Axes; and in the Hyperbola it is a mean Proportional between the transverse Axis and the Parameter.

Conjugate Diameters *of an Ellipsis*, or *Hyperbola*, are two Diameters so drawn, that one of them is parallel to the Ordinates of the other.

Conjugate Hyperbola's. If there be two opposite Hyperbola's, A M, *a m*, whose principal Axis is



the Line A *a*, and Conjugate Axis the Line B *b*; and if there be two other Hyperbola's, whose principal Axis is the Line B *b*, and conjugate one the Line A *a*, then these four Hyperbola's are called *Conjugate Hyperbola's*, the two former opposite ones, being Conjugates to the latter.

Conjunction, in Astronomy, is the Meeting of the Stars and Planets in the same Degree of the Zodiac, and is either *apparent* or *true*.

Conjunction *apparent*, is when a right Line supposed to be drawn through the Centres of the two Planets, does not pass through the Centre of the Earth, but through the Eye.

Conjunction *true*, is when that right Line being produced, passes through the Centre of the Earth.

Conoid, is a Solid produced by the Circumvolution of a Section of the Cone about its Axis, and may be either a

Conoid *Elliptical*. See *Spheroid*.

Conoid *Hyperbolical*. See *Hyperbolical Conoid*.

Conoid *Parabolical*. See *Parabolical Conoid*.

The Sections of all Conoids, made by Planes cutting them, will be the same as the Sections of a Cone.

Conscribed, the same with *Circumscribed*. Which see.

Consectary, is a Deduction, or Consequence, drawn from a preceding Proposition; and is the same with *Corollary*.

Consequent, in Mathematics, is the latter of the two Terms of a Ratio: As suppose the Ratio be of A to B, then B is said to be the Consequent.

Console, in Architecture, is an Ornament cut upon the Key of an Arch, which has a Projecture or Jetting, and upon occasion, serves to support little Cornices, Busts, and Bases.

Consonance, in Music, is the Agreement of two Sounds, the one grave, and the other acute, being compounded together by such a Proportion of each, as proves agreeable to the Ear.

An Unison is the first *Consonance*, an Eighth the second, a Fifth the third; and then follows the fourth, and the Thirds and Sixths, Major and Minor. There are other Consonances, being the Doublets, or other Repetitions of the former. But there can be only seven or eight simple Consonances, the perfect ones being the Unison, Eighth, and Fifth, with their Compounds.

Constant Quantities, are such that remain the same, while others increase, or decrease. So the Semi-diameter of a Circle is a constant Quantity; for while the Absciss and Semi-Ordinates increase, it remains the same.

Constellation, or *Asterism*, is a Company of fixed Stars, imagined (by the Ancients) to represent the Name of something, and commonly called by the Name of that thing. Of these there are forty-eight, twenty-three being Northern, and twenty-five Southern ones.

Some Zealots have been so vain, as to attempt the changing the Names of the Constellations, in giving them Appellations taken from the Scriptures, as venerable *Bede*, and *Julius Schillerius*, who called, for Example, *Aries*, *Peter*; *Taurus*, *Andrew*; *Andromeda*, the *Sepulchre of Christ*; *Hercules*, the *wise Men coming from the East*; the *great Dog*, *David*, &c.

And *Weigelius*, a *quondam* Professor of Mathematics at *Geneva*, in his *Cœlum Heraldicum*, has transferred the chief Princes of *Europe* into the Heavens; as the *Great Bear* is changed into the Elephant of the Kingdom of *Denmark*, &c.

But this Boldness ought not to be approved of; which, instead of being useful, will beget Confusion in Astronomy: For the Names and Signs of the Ancients are to be retained, not only because there cannot be better ones put for them, but that the Writings of Astronomers, that have been as yet publish'd, may be understood, and the Observations of the Ancients compared with those of the Moderns.

Con-

Constipation, is when the Parts of any Body acquire a closer Texture than what they had before.

Constriction, is the crouding the Parts of any Body close together, in order to Condensation.

Construction *of Equations*, in Algebra, is the finding the unknown Quantities or Roots of an Equation, either by straight Lines, or Curves.

1. All simple Equations, or those of one Dimension, may be constructed, by resolving the Fractions that the unknown Quantity is equal to, into proportional Terms.

2. All Quadratics may be constructed by means of a right Line, and a Circle.

3. All cubic or biquadratic Equations may be constructed by means of a Circle, or a given Parabola, or Hyperbola.

4. All Equations may be constructed by the Intersection of two Loci. And the most simple Loci that will construct an Equation, may be found thus: Extract the square Root of the highest Power of the unknown Quantity, and if there be no Remainder, then each of the two Loci must be of the same Number of Degrees as there are Units contained in that square Root.

But if there be a Remainder, the same is equal, less, or greater than the square Root: If it be equal, or less, the Degree for one of the Loci will be the Root itself; and for the other, that Root *plus* Unity. If the Remainder be greater than the Root, then the Degree of both the Loci shall be the Root *plus* Unity.

As, if it were required to find the most simple Loci that will construct an Equation of 12 Dimensions, the square Root thereof is 3, and the Remainder is 3; whence, a Locus of the third Degree, and another of the fourth, will construct the Equation. Moreover, to find the two most simple Loci, that will construct an Equation of 37 Dimensions, having extracted the square Root of 37, which is 6, the Remainder will be 1, being less than 6; therefore one of the Loci must be of the 6th, and the other of the 7th Degree. And these Loci will do for Equations of 38, 39, 40, 41, and 42 Dimensions.

Francis Vieta, in his *Canonica Recensione Effectionum Geometricarum*, and *Marinus Ghetaldus*, in his *Opus posthumum de Resolutione & Compositione Mathematica*, as also *Descartes*, in his *Geometria*, have shewn how to construct simple and quadratic Equations. *Descartes* too, has shewn how to construct cubic and biquadratic Equations, by the Intersection of a Circle and a Parabola. So also has Mr. *Baker*, in his *Clavis Geometrica*. But the genuine Foundation of all these Constructions was first laid and explained by *Renatus Slusius*, in his *Mesolabium*, part 2. This Doctrine is also pretty well handled by *De la Hire*, in a little Treatise, entitled, *La Construction des Equations Analytiques*, joined to his Conic Sections. Sir *Isaac Newton*, at the End of his Algebra, has given the Construction of cubic and biquadratic Equations mechanically; and by the Conchoid and Cissoid, as well as the Conic Sections. See also, Dr. *Halley*'s Construction of cubic and biquadratic Equations; as also Mr. *Colson*'s, in the *Philosophical Transactions*; and the Marquis *De l'Hospital*'s *Traite Analytique des Sections Coniques*.

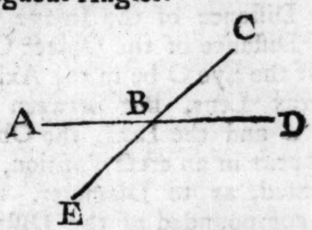
Construction, in Geometry, is the drawing such Lines as are previously necessary for the making any Demonstration appear more plain and undeniable.

Contact, is when one Line, Plane, or Body, touches another; and the Parts that do thus touch, are

are called the *Points*, or *Places of Contact*.

Contiguity, is only the Surface of one Body's touching that of another. But *Continuity* is the immediate Union of the Parts which compose any natural Body; so that one cannot tell where one begins, and another ends.

Contiguous Angles, in Geometry, are such as have one Leg common to each Angle; and are sometimes called *adjoining Angles*: As the Angles ABC, CBD; CBD, DBE; DBE, EBA, are contiguous Angles.



The Sum of any two contiguous Angles is always equal to two right Angles.

Continent, in Geography, is a great Extent of Land, comprehending several Regions and Kingdoms; and which is not interrupted or separated by Seas. Of these there are reckoned four, *viz. Europe*, *Asia*, *Africa*, and *America*.

Contingent Line, the same with *Tangent Line*. This Line, in Dialling, is supposed to arise from the Intersection of the Plane of the Dial and Equinoctial; and is so called, because it is a Tangent to a Circle, drawn upon the Plane of the Dial, and is at right Angles to the substilar Line.

Continual Proportionals. If there be such a Series of Quantities, that the first is in the same Proportion to the second, as the second to the third, and the third to the fourth, and the fourth to the fifth, and so on, they are called *continual Proportionals*.

Continued Quantity, is that whose Parts are inseparably joined and united together, so that you cannot distinguish where one begins and another ends.

Contra-Mure, in Fortification, is a little Wall built before another Partition-Wall, to strengthen it, so that it may receive no Damage from the adjacent Buildings.

Contrate-Wheel, is that Wheel in Watches, which is next to the Crown, whose Teeth and Hoop lie contrary to those of the other Wheels; from whence it takes its Name.

Contravallation, or the *Line of Contravallation*, in Fortification, is a Trench guarded with a Parapet, and usually cut round about a Place by the Besiegers, to secure themselves on that side, and to stop the Sallies of the Garison. It is without Musket-shot of the Town; so that the Army forming a Siege, lies between the Lines of *Circumvallation*, and *Contravallation*.

Contre-Queue d'yronde, a Term in Fortification, the same as *Counter-Swallow's-Tail*.

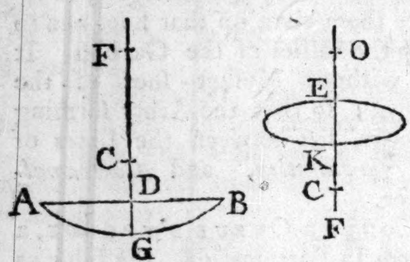
Converging, (or *Convergent*) Rays, in Optics, are those Rays that, issuing from divers Points of an Object, incline towards one another, till at last they meet, and cross, and then become *diverging Rays*; as the Rays AB, CB, do converge till they come to the Point B, and then they diverge, and run

off from each other in the Lines BD, BE.

CONVERSE, in Mathematics. One Proposition is called the Converse of another, when, after a Conclusion is drawn from something *supposed* in the *converse* Proposition, that *Conclusion* is *supposed*; and then that, which in the other was *supposed*, is now drawn as a *Conclusion* from it. As thus; when two Sides of a Triangle are equal, the Angles under their Sides are equal; and on the converse, if those Angles are equal, the two Sides are equal.

CONVEX-GLASS, or *Lens*, is a Glass that has one of its Superficies plain, and the other spherically convex. This, by some, is called a *Plano-Convex*.

1. If A G B be a Convex Glass, and F the Focus of Parallel Rays,



and C the Centre of the Glass, then will $FD = 2CG - \frac{2}{3}GD$. And so if two thirds of the Thickness G D be so small, as to be neglected, as often happens, then will Parallel Rays unite at the Distance of the Glass's Diameter, whether the flat or convex Side of the Glass be turned towards the luminous Body.

2. If KE be a Glass Convex both ways, or a double Convex, and C, O, be the Centres of the Convexities, and F the Focus of Parallel Rays falling upon the Glass, then will $KO + CE : 2\,OE :: KO : FK$.

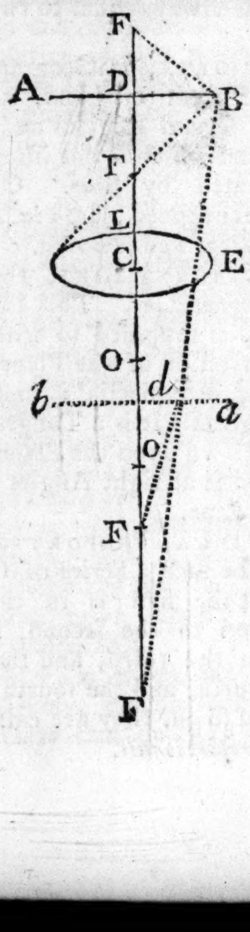
3. The Focus of diverging Rays is farther distant from the Glass than the Focus of Parallel Rays; and the Distance of the Focus in the former case is greater, or less, according to the greater or less Distance of the radiating Point.

4. If an Object be in the Focus of a convex Glass, and the Eye on the other side of the Glass, the Object will appear erect and distinct.

5. The Images of Objects, opposite to a *Lens*, any how convex, are distinctly painted and inverted in the Focus thereof.

6. The Image *b a* of an Object A B, delineated in the Focus *d*, of a convex Glass, is to the Object itself, as to Diameter, in the Ratio of the Distance of the Image C*d*, to the Distance of the Object C D.

7. If the Eye O be in the Axis of a convex Lens, but between the Focus *d* and the Lens, the Object will appear in an erect Position, but augmented, as to Diameter, in a Ratio compounded of the Distance of the Point F, to which the Ray



BE tends unrefracted from the Lens EL, to the Diſtance of the Eye OL, from the ſame; and of OD, the Diſtance of the Object AB, from the Eye to the Diſtance FD of the ſame Object, from the Point to which the Rays tend unrefracted, that is, FL : OD :: OL : FD.

8. And if the Eye O be beyond the Focus, the Point F will fall beyond the Object; and then FL : FD :: OD : OL.

9. If the Object AB be ſo far diſtant from the Glaſs, that the Ray BE, refracted to the Eye O, diverges from the Point F in the Axis, between the Glaſs and the Object, then it will appear inverted, and the apparent Magnitude will be to the true Magnitude, in the Ratio compounded of FL to FD, and of OD to OL.

Copernican System *of the World*, is the ancient *Pythagorean* Syſtem, which *Nicholas Copernicus*, a *German*, in a Treatiſe publiſh'd in *Latin* about the Year 1566, revived, after it had been for many Years thrown out of doors; and it ſuppoſes, that the Earth and the Planets revolve about the Sun, which ſtands ſtill, as their Centre; and that the diurnal Motion of the Sun and fixed Stars is not real, but imaginary, ariſing from the Motion of the Earth about its Axis.

Corbeils, in Fortification, are little Baſkets about a Foot and an half high, eight Inches broad at the bottom, and twelve at the top; which, being filled up with Earth, are commonly ſet one againſt another upon the Parapet, or elſewhere, leaving certain Port-Holes, from whence to fire upon the Enemy under Covert.

Corbet, in Architecture, is a ſhort Piece of Timber, placed in a Wall, with its End ſticking out ſix or eight Inches; and the under Part of this End ſticking out is ſometimes cut into the Figure of a *Boultin*, *Ogee*, and ſometimes of a *Face*, &c. the upper Side being flat.

The Corbets are uſually placed, for Strength's ſake, juſt under the Semi-Girder of a Platform, and ſometimes under the Ends of Camber-Beams.

Cor Caroli, an Extra-Conſtellated Star in the Northern Hemiſphere, ſituated between *Coma Berenices* and *Urſa Major*, ſo called in Honour of King *Charles* II.

Cor Hydræ, a Fixed Star of the firſt Magnitude in the Conſtellation *Hydra*. Its Longitude is 142 deg. 49 min. Latitude 22 deg. 23 min. and Right Aſcenſion 133 deg. 20 min.

Cor Leonis. See *Regulus*, or *Baſilicus*.

Cordon, in Fortification, is a Row of Stones, made round on the Outſide, and ſet between the Wall and the Fortreſs, which lies aſlope, and the Parapet, which ſtands perpendicular, after ſuch a manner, that this Difference may not be offenſive to the Eye; whence thoſe Corders ſerve only as Ornaments, ranging round about the Place, being only uſed in Fortifications of Stone-Work: For in thoſe made with Earth, the void Space is filled up with pointed Stakes.

Cords, in Muſic, are the Sounds produced by an Inſtrument or Voice.

Corinthian Order, *of Architecture*, being the fourth Order, is the richeſt and the moſt delicate of them all, and was invented by an Architect of *Athens*. Its Capital is adorned with Rows of Leaves, and of eight Voluta's, which ſupport the *Abacus*. The Height of its Column is ten Diameters, and its Cornice is ſupported by Modillions.

Cornea, is the hinder external Tunic of the Eye, being like a pellucid Horn, very firm, of a ſpherical,

cal, or rather ſpheroidical Figure, ſtanding out behind the remaining Part of the Ball of the Eye, and conſolidating the Eye and *Sclerotica*.

Corniche, or *Cornice*, is the third and higheſt Part of the Entablature, and commonly ſignifies the uppermoſt Ornament of any Wainſcot, *&c.* in regard to the Pillar; and is different, according to the different Orders of Architecture. In the *Tuſcan* it is without Ornament; and this Pillar, of all others, has the leaſt Mouldings. The *Doric* is adorn'd with *Dentils*, like the *Ionic*, and which ſometimes has its Mouldings cut into it. The *Corinthian* Pillar, of all others, has the moſt Mouldings, and thoſe very often cut with Modillions, and ſometimes *Dentils*. The Compoſite has its Dentils and Mouldings cut, with its Channels or Chamferings under its Platfond.

Cornish-Ring *of a Gun*, is the next from the Muzzle-Ring backwards.

Corollary, or *Conſectary*, is a Conſequence drawn from ſomething that has been already demonſtrated; as, when it is demonſtrated, *That two Semi-circles can cut each other but in one Point*, therefore it follows from thence, *That two whole Circles can cut one another but in two Points*.

Corona, in Architecture, is properly the flat and moſt advanced Part of the *Cornice*, called by us the *Drip*, becauſe it defends the reſt of the Work from Wind and Water. But by *Vitruvius* it is often taken for the whole *Cornice*.

Corona Borealis, or the *Northern Garland*, a Conſtellation in the Northern Hemiſphere, conſiſting of about twenty Stars.

Corona Meridionalis, a Southern Conſtellation, of thirteen Stars.

Corpuscles, in Natural Philoſophy, ſignify the minute or ſmall Parts of a Body. And

Corpuscular Philosophy, is the Explanation of Things, and giving an Account of the Phænomena of Nature by the Motions and Affections of the minute Parts of Matter.

Coridor, in Fortification, is the Covert-Way lying round about the whole Compaſs of the Fortifications of a Place, between the Outſide of the Moat and the Palliſadoes.

Corvus, a Southern Conſtellation, conſiſting of ſeven Stars.

Co-Secant, is the Secant of an Arch, which is the Complement of another, to 90 Degrees.

Co-Sine, is the Right Line of an Arch, which is the Complement of another, to 90 Degrees.

Cosmography, is a Deſcription of all the ſeveral Parts of the viſible World, according to their Numbers, Poſitions, Motions, Magnitudes, and their other Properties.

Co-Tangent, is the Tangent of an Arch, which is the Complement of another, to 90 Degrees.

Co-Versed Sine, is the remaining Part of the Diameter of a Circle, after the Verſed Sine is taken from it.

Covert-Way, in Fortification, is a Space of Ground level with the Field, on the Edge of the Ditch, about twenty Foot broad, ranging quite round the Half-Moons, and other Works, towards the Country.

This is otherwiſe called *Coridor*, and has a Parapet raiſed on a Level, together with its Banquets and Glacis, which from the Height of the Parapet muſt follow the Parapet of the Place, till it is inſenſibly loſt in the Field. It has alſo a Foot-Bank.

One of the greateſt Difficulties in a Siege, is to make a Lodgment on the Covert-Way, becauſe the Beſieged uſually palliſado it along the

Middle,

Middle, and undermine it on all ſides. This is called the *Counterſcarp*, becauſe it is on the Edge of it.

Coving-Cornice, is ſuch a Cornice, that has a great Caſemate, or Hollow in it, which is commonly lathed and plaiſter'd upon Compaſs Sprockets, or Brackets.

Count-Wheel, is a Wheel in the ſtriking Part of a Clock, moving round once in twelve or twenty-four Hours. This by ſome is called the *Locking-Wheel*, becauſe it has commonly eleven Notches in it at unequal Diſtances from one another, in order to make the Clock ſtrike, and it is driven round by the Pinion of Report.

Counter-Approaches, are Works made by the Beſieged, to hinder the Approach of the Enemy; and when they deſign to attack them in Form.

Counter-Battery, is one raiſed to play againſt another.

Counter-Breast-Work, the ſame with *Falſe Bray*.

Counter-Forts, are certain Pillars and Parts of the Walls of a Place, diſtant from fifteen to twenty Foot one from another, which are advanced as much as poſſible in the Ground, and joined to the Height of the Cordon by Vaults, to ſupport the Way of the Rounds, and part of the Rampart; as alſo to fortify the Wall, and ſtrengthen the Ground; but are not now of much Uſe, unleſs in large Fortifications.

Counter-Fugue, in Muſic, is when the Fugues proceed contrary to one another.

Counter-Guards, in Fortification, are large Heaps of Earth, in figure of a Parapet, raiſed above the Moat, before the Faces, and the Point of the Baſtion, to preſerve them; and then they conſiſt of two Faces, making an Angle-Saliant, and are parallel to the Faces of the Baſtion.

Counter-Mine, is a ſubterraneous Paſſage, made by the Beſieged, in ſearch of the Enemy's Mine, to give air to it, to take away the Powder; or by any other means to fruſtrate the Effect of it.

Counter-Part, a Term in Muſic, only denoting one Part to be oppoſite to another: As, the Baſe is ſaid to be the Counter-part to the Treble.

Counter-Point, is the old manner of compoſing Pieces of Muſic, before Notes of different Meaſures were invented; which was, to ſet Pricks or Points one againſt another, to denote the ſeveral Concords. The Length or Meaſure of which Points was ſung according to the Quantity of Words or Syllables whereto they were applied.

Counterscarp, is that Side of the Ditch that is next to the Country; or properly the Talus that ſupports the Earth of the Covert-Way; tho' by this Word is underſtood often the whole Covert-Way, with its Parapet and Glacis. And ſo it muſt be underſtood, when it is ſaid, *The Enemy lodged themſelves on the Counterſcarp*.

Counter-Swallows-Tail, is an Outwork in Fortification, in the figure of a ſingle Tenaille, wider towards the Place, that is, at the Gorge, than at the Head, or next to the Country.

Counter-Tenor, one of the mean or middle Parts of Muſic, being called ſo, becauſe it is oppoſite to the Tenor.

Course, in Navigation, is that Point of the Compaſs, or Coaſt of the Horizon, on which the Ship is to be ſteered from Place to Place; or it is more properly the Angle that is made by a Tangent to the Meridian, and an infinitely ſmall Part of a *Rhumb-Line* at the Point of Contact.

Courtine, or *Courtain*, in Fortification, is the Front of the Wall between the Flanks of two Bastions; or the longest Straight Line that runs round the Rampart, drawn from one Flank to the other, being border'd with a Parapet five Foot high, behind which the Soldiers stand, to fire upon the Covert-Way, and into the Moat.

Cronical. See *Acronical*.

Cross-Multiplication, is a Method, used by Workmen, of casting up superficial Dimensions of Feet, Inches, and Parts, by first setting down a Length taken in Feet and Inches, and setting the Feet and Inches of another Length, by which the former Length is to be multiplied, directly under the Feet and Inches of that Length; and then multiplying the Feet by the Feet, and (cross-wise) the Inches of one Length by the Inches of the other, and dividing the Sum of the Product by 12, and multiplying the Inches by the Inches, and dividing them by 144.

Cross-Staff, or *Fore-Staff*, is a Mathematical Instrument of Box, or Pear-Tree, consisting of a square Staff, of about three Foot long, having each of the Faces thereof divided like a Line of Tangents, and four Cross-Pieces of unequal Lengths to fit on to the Staff, the Halves of which are as the Radius's to the Tangent Lines on the Faces of the Staff. This Instrument is used in taking the Altitudes of the Celestial Bodies at Sea.

Crossiers, are four Stars in figure of a Cross, serving those that sail in the Southern Hemisphere, to find the South Pole.

Crotchet, a Term in Music, being the fifth Note of Time.

Crown, in Geometry, is a plain Ring, included between two concentric Peripheries, and the Area thereof will be had by multiplying its Breadth by the Length of the Middle Periphery.

Crowned Horn-Work, is a *Horn-Work* with a *Crown-Work* before it.

Crown-Post, is a Post which, in some Buildings, stands upright in the Middle, between two principal Rafters, and there goes *Struts* or *Braces* from it to the Middle of each Rafter.

Crown-Wheel *of a Watch*, is the upper Wheel next to the Ballance, which by its Motion drives it, and in Royal Pendulums is called the *Swing-Wheel*.

Crown-Works, in Fortification, are certain Bulwarks advanced towards the Field to gain some Eminence, consisting of a large *Gorge*, and two Wings that fall on the Counterscarp near the Faces of the *Bastion*; so that they are defended by them, and next to the Field shew an entire Bastion, being between two *Demi-Bastions*, the Faces whereof look towards one another.

Crystalline *Humour of the Eye*. This Humour lies immediately next to the Aqueous within the Opening of the Tunica Uvea, and, like a Glass put over a Hole, collects and refracts the Rays of Light falling upon it, being very pellucid, in figure of a Lens unequally Convex.

Kepler, in *Paralip. in Vitellionem*, cap. 5. pag. 167. thinks, that the foremost Side of the crystalline Humour is the Segment of a Spheroid, generated by the Revolution of an Ellipsis about its Axis; and the hinder Side, the Segment of an hyperbolic Conoid, made from the Revolution of an Hyperbola about its Axis.

But *Schottus*, in *Libro de Univers. Nat. & Art.* part 1. lib. 2. pag. 68. says, That the crystalline Humour is not of the same Figure in all Men, and even in the same Person, it

it varies according to his Age; for it is more round in some than others, and in a Person of full Age it is turgid, but in old Age it is almost flat.

CUBATURE *of a Solid*, is the Measuring the Space contained in it, or the finding the solid Content of it.

CUBE, is a solid Body, consisting of six equal Sides, being all Squares. The Solidity of any Cube is found by multiplying any one of its Sides, or Faces by the Height.

Cubes are to one another, in the triplicate Ratio of their Diagonals, or of the Sides of their Faces.

CUBE-ROOT *of any Number or Quantity*, is such a Number or Quantity, which, if multiplied into itself, and then again the Product thence arising by that Number or Quantity, (being the cube Root,) this last Product shall be equal to the Number or Quantity whereof it is the cube Root; as 2 is the cube Root of 8, because two times 2 is 4, and two times 4 is 8; and $a+b$ is the cube Root of $a^3 + 3abb + 3baa + b^3$.

Every cube Number has three Roots; one real Root, and two imaginary ones: as the cube Number 8 has one real Root 2, and two imaginary Roots, *viz.* $\sqrt{-3}-1$ and $\sqrt{-3}+1$. And, generally, if a be the real Root of any cube Number, one of the imaginary Roots of that Number will be

$$\frac{a+\sqrt{-3aa}}{2},$$ and the other $$\frac{a-\sqrt{-3aa}}{2}.$$

CUBIC EQUATION, in Algebra, is such an one wherein the unknown Quantities arise to three Dimensions; as $x^3 = a^3 - b^3$, or $x^3 + rxx = p^6$, or $x^3 + fxx - abx = mmn + pqr$, &c.

All cubic Equations have three Roots, either all real, or one real, and two imaginary.

All cubic Equations may be reduced to this Form, $x^3 + qx + r = o$; wherein the second Term is wanting; and they may be extracted if q be affirmative, or even negative, provided that $\frac{q^3}{27}$ be not greater than $\frac{1}{4} rr$.

If $x^3 + px - q = o$ be a cubic Equation, which has always two imaginary Roots, since q is negative, and the real Root be wanted: suppose $x = u + z$; then will u be $=$

$$\sqrt[3]{\tfrac{1}{2}q + \sqrt{\tfrac{1}{4}qq + \frac{p^3}{27}}}.$$ And since $u - \frac{p}{3u} = x$; therefore if the said known Value of u be put for the same in this Equation, we shall have the Value of x in known Terms. In like manner, when q is affirmative in the given cubic Equation, and it has two imaginary Roots, which is when $\frac{1}{4}qq$ is greater than $\frac{p^3}{27}$; the Value of u will be $=$

$$\sqrt[3]{\tfrac{1}{2}q \pm \sqrt{\tfrac{1}{4}qq - \frac{p^3}{27}}},$$ and so there will be a real Value of x. But when all the Roots of the given cubic Equation are real, they cannot be found by this means; because in this Case $\frac{1}{4}qq - \frac{p^3}{27}$ will be a negative Quantity, and so its square Root is an impossible Quantity. But these Roots may be found by the Tables of Sines or the Trisection of an Arch of a Circle.

First find the Sine which is to the Radius, as $\frac{3}{2}\frac{q}{p}$ to $\sqrt{\frac{1}{3}p}$, and

 having

having found the Degrees of the Arch anſwerable thereto, take $\frac{1}{3}$ part of thoſe Degrees, and double the Sine of them; then, if a fourth Proportional be found to this double Sine, $\sqrt{\frac{1}{3}p}$, and the Radius; that fourth Proportional will be one Value of x in the cubic Equation $x^3 \pm px + q = o$.

The real Root of a cubic Equation $x^3 . px . q = o$, whoſe two others are imaginary, may be otherwiſe found thus: let the Sine of the third Term px be $+$, then the Difference between two mean Proportionals

between $\frac{3q}{2p} + \sqrt{\frac{9qq}{4pp} + \frac{1}{9}pp}$

and $-\frac{3q}{2p} + \sqrt{\frac{9qq}{4pp} + \frac{1}{9}pp}$, will be the Value of x. And if the Sine of px be $-$, the Sum of thoſe mean Proportionals will be the Value of x. Or ſuppoſing $a = \sqrt{\frac{1}{3}p}$, and $b = \frac{3q}{2p}$, the Difference or Sum of two mean Proportionals between $b + \sqrt{aa + bb}$ and $-b + \sqrt{aa + bb}$ will be the Value of x.

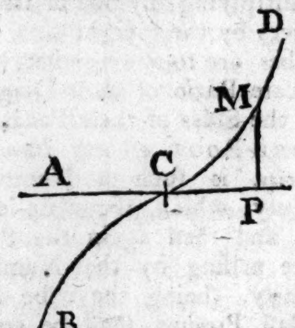
Cubic Foot *of any Subſtance*, is ſo much of it as is contained in a Cube, whoſe Side is one Foot.

Cubic *Hyperbola*, is a Figure expreſſed by the Equation $xy^2 = a$, having two Aſymptotes, and conſiſting of two Hyperbola's, lying in the adjoining Angles of the Aſymptotes, and not in the oppoſite Angles, like the *Apollonian* Hyperbola; being otherwiſe called by Sir *Iſaac Newton* in his *Enumeratio Linearum Tertii Ordinis*, an Hyperboliſmus of a Parabola; and is the 65th Species of his Lines, according to him.

Cubic Number, is that Number which is produced by multiplying any Number by itſelf, and then again the Product by that Number; as, 27 is a Cubic Number, ſince 3 multiplying 3, produces 9; and again, 3 multiplying 9, produces 27.

The Difference of two cube Numbers, whoſe Roots differ by Unity, is equal to the Aggregate of the Square of the Root of the greater, double the Square of the leſs, and the leſs Root.

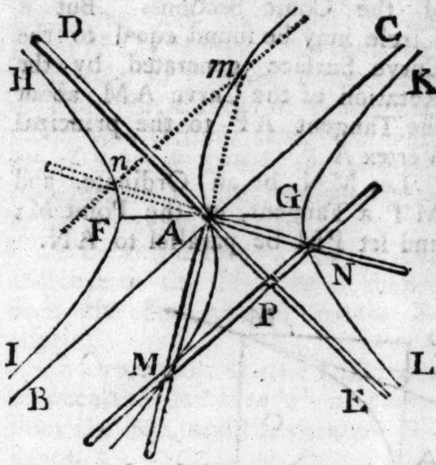
Cubic Parabola, a Curve as BCD of the ſecond Order, having



two infinite Legs CD, CB, tending contrary ways. And if the Abſciſs AP, x, touches the Curve in C, the relation between AP (x) and PM (y) is expreſſed by the Equation $y = ax^3 . bx^2 . cx . d$. or when A falls in C, by the Equation $y = ax^3$. which is the moſt ſimple Equation of the Curve.

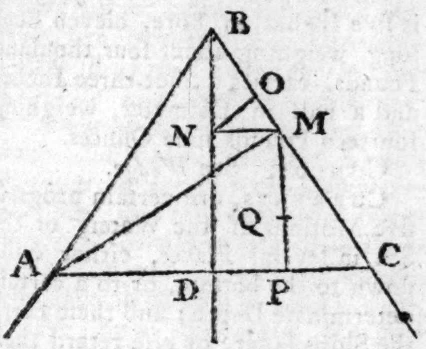
If it be required to deſcribe the cubical Parabola by a continued Motion, you may do it thus, by means of a Square and the equilateral Hyperbola: Thro' a given Point A, draw the Right Line CAB, and DAE at right Angles to it, and draw FAG at half right Angles to CAE or DAB, and let DE, BC be Aſymptotes to the equilateral Hyperbola's HFI, KGL; then take a ſingle Square MAN, and a double one DMPN. Faſten the Angle of the ſingle Square MAN in the Centre A, ſo as to be moveable about the ſame. Then if the Leg DP of the double Square be moved or ſlid along the Aſymptote DAE, and at

at the same time the Intersection of the Leg A N of the single Square,



and the Leg P N of the double Square moves along the Curve K L of the equilateral Hyperbola; the Intersection M of the other Leg A M of the single Square, with the Leg P M of the double Square, will describe the Part A M of the cubical Parabola. And if the Intersection *n* of the Sides of the single and double Squares be moved along the other opposite Hyperbola H F I, the Intersection *m* of the other Sides will describe the other Part A *m* of the cubic Parabola.

Otherwise, by means of Points. Let A B C be an Isosceles Triangle, and

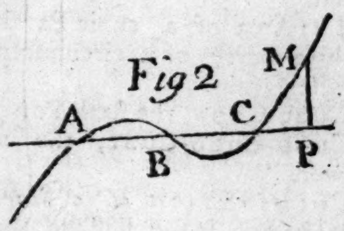


B D perpendicular to the Base A C. Take any Point M in the Side B C, and draw the right Line AM; from M draw the Perpendiculars MN and MP to BD and AC. Draw NO parallel to AM. Then if P Q be made equal to N O, the Point Q will be one Point thro' which the cubical Parabola must pass. And after the same manner may any number of Points be found. There are several other ways of finding Points of the cubical Parabola; as, by means of two Squares, by means of the common Parabola, &c. But let this be sufficient.

In the cubical Parabola, if A Q be the Axis, and Q N the Base, and

R M be parallel to A Q; then will R M be always as $\overline{QN}^3 - \overline{QR}^3$.

Also in the second Figure, if the Right Line A P cuts the cubical

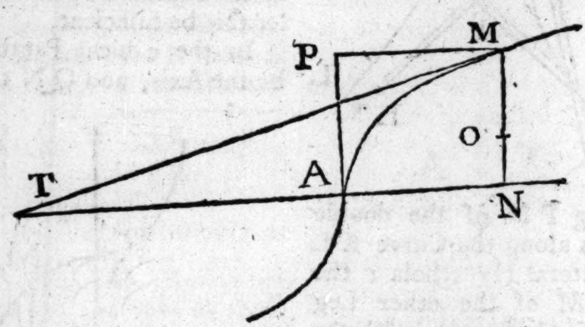


Parabola A B C M in three Points A, B, C, and from any Point P be drawn the Right Line or Ordinate P M, cutting the Curve in one Point M only; then will P M be always as the solid AP × BP × CP; which is an essential Property of this Curve.

And hence it is easy to construct a cubic Equation $x^3 + aax = b^3$ by the Intersection of this Curve, and a right Line. See the Construction of a cubic Equation by means of the cubic Parabola, and a right Line by Dr. *Wallis*, in his *Algebra*: As also the Construction of Equations of six Dimensions, by means thereof and a Circle by Dr. *Halley*, in a Lecture formerly read at *Oxford*.

The Curve of this Parabola cannot be rectified, not even by means of the Conic Sections. But a Circle may be found equal to the Curve Surface generated by the Rotation of the Curve AM about the Tangent AP to the principal Vertex A.

Let MN be an Ordinate, and MT a Tangent, at the Point M; and let PM be parallel to AN.



Divide MN in the Point O, in such manner that MO be to ON as TM is to MN. Then a mean Proportional between TM + ON and $\frac{1}{3}$ of AN will be the Semi-Diameter of a Circle equal to the Superficies described by that Rotation.

The Area of a cubic Parabola, is three fourths of its circumscribing Parallelogram.

Cubo-Cube, the sixth Power.

Cubo-Cubo-Cube, the ninth Power.

Culmination *of a Star*, in Astronomy, is the Passage thereof over the Meridian: And so a Star is said to culminate when it passes over the Meridian.

Culvering, a Species of Ordnance; of which there are three sorts, *viz.* the *Extraordinary*, the *Ordinary*, and the *least-sized Culvering*.

Culvering *Extraordinary*, is five Inches and a half in Bore, thirteen Foot long, weighs four thousand eight hundred Pounds. Its Load is about twelve Pounds, and it carries a Shot of five Inches and a half in Diameter, weighing twenty Pounds.

Culvering *Ordinary*, weighs four thousand five hundred Pounds, and twelve Foot long: The Weight of the Ball seventeen Pounds five Ounces.

Culvering *of the least size*, is five Inches in Bore, eleven Foot long, weighing about four thousand Pounds, carries a Shot three Inches and a half in Diameter, weighing fourteen Pounds nine Ounces.

Cuneus. See *Wedge*.

Currents, are certain progressive Motions of the Waters of the Sea in several Places, either quite down to the bottom, or to a certain determinate Depth; and these carry the Ships faster, or else retard their Motion, according as the Current sets with or against the Ship's Motion.

Cur-

Cursor, in Mathematical Inftruments, is any fmall Piece that flides; as, the Piece in an Equinoctial Ring-Dial that flides to the Day of the Month. Likewife the little Ruler or Label of Brafs, being divided like a Line of Sines, and fliding in a Groove along the middle of another Label, reprefenting the Horizon in the Analemma, is called a *Curfor*.

Curtated Distance, is the Diftance of the Place of a Planet from the Sun reduced to the Ecliptic.

Curtation, is the Difference between the Diftance of a Planet from the Sun, and the curtated Diftance.

Curvature. This fignifies Crookednefs.

Curve, the fame as Crooked.

Curves, in Geometry, are fuch Lines, which running on continually in all Directions, may be cut by one right Line in more Points than one. Or which include a Space with one right Line, either returning into themfelves or making infinite Excurfions.

Curves are divided into Algebraical, or Geometrical, and Tranfcendent. And Geometrical ones into thofe of the firft, fecond, third, &c. Order: See the Word *Geometrical Curve*. Exprefs Writings upon Curve Lines, befides the Conic Sections, are *Archimedes*'s *De Spiralibus*. — Dr *Barrow*'s *Lectiones Geometricæ*.— Sir *Ifaac Newton*'s *Enumeratio Linearum tertii Ordinis*.— *Sterling*'s *Illuftratio tractatus Domini Newtoni de Lineis tertii Ordinis*.— Mr. *Mac-Laurin*'s *Geometria Organica*.—Mr. *Brakonridge*'s little Treatife of Curves.— There are befides, feveral fmall Difcourfes upon Curves, in the *Acta Eruditorum*, the *Memoires de l'Academie Royale des Sciences*, &c.

Two of the Ufes of Curve Lines are to folve Problems by their Interfections, and to conftruct Equations: As if the Problem of *Ward*, in his *Young Mathematician's Guide*, about the May-pole upon a Hill, was to be conftructed geometrically; the eafieft and moft natural way of doing it, would either be by an Ellipfis, whofe focal Diftance is the given Bafe, and tranfverfe Axis the Sum of the Sides of the Triangle, and a Square whofe angular Point is moveable about one Focus, and Ruler moveable about the other Focus. Or elfe by defcribing a Curve form'd (by moving a Square about a given Point upon a Plane, and a Ruler about another given Point upon that Plane, in fuch manner that the Ruler always paffes through a given Point in one fide of the Square) with the Interfection of the Ruler and the other fide of that Square, and then taking a Thread of the given Length, doubling it, and putting it about the given Points upon the Plane, and moving it titely about till the Point ftretching it falls in the faid Curve.

Dr. *Wallis*, in chap. 70. of his Hiftory of *Algebra*, fays, that Equations of 5 or 6 Diameters, may be conftructed by two Conic Sections. And if higher Equations are to be conftructed, there muft be more Conic Sections ufed to the Performance. But here the Doctor is miftaken, as is now well known by a Geometrician even of the fecond Clafs; whence it is plain, the Doctor did not well underftand this Doctrine.

Cut-Bastion. See *Baftion*.

Cuvette, in Fortification, is a deep Trench about four Fathom broad, which is commonly funk in the middle of the great dry Ditch till you come to Water, and ferves both to prevent the Befiegers Mining, and alfo the better to keep off the Enemy.

Cycle, is a perpetual Revolu-

tion of certain Numbers, which successively go on from the first to the last, and then return again to the first, and so circulate perpetually. There are three principal Cycles, *viz.* the *Cycle of Indiction*, the *Cycle of the Moon*, and the *Cycle of the Sun*.

Cycle *of Indiction*, is a Revolution of fifteen Years, which first began the third Year before Christ.

Chronologers disagree about the Time that the Cycle of Indiction began; and also concerning the Use that the *Romans* invented it for: But, according to vulgar Computation, the Year of Christ's Nativity was the third of this Cycle; and thus we are certain, that it was established by *Constantine* in the Year 312.

If you subtract 312 from the Year given, and divide the Remainder by 15, and what remains, omitting the Quotient, is the Year of the *Roman* Indiction; or if 3 be added to the given Year, and the Sum be divided by 15, the Remainder, omitting the Quotient, will be the Year of the Indiction.

Cycle *of the Moon*, is a Revolution of nineteen Years, which began one Year before Christ, in which space of time the new and full Moons return to the same Days of the *Julian* Year they were on before, and she begins again her Course with the Sun.

The Cycle of the Moon, after three hundred and twelve Years, will not restore the new and full Moons to the same Day of the *Julian* Year, but there will be an Error of one whole Day.

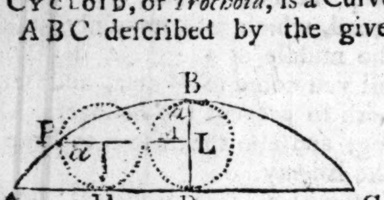
Cycle *of the Sun*, is a Revolution of twenty-eight Years, in which time the same Dominical Letter comes about again in the same Order, and Leap Years expire, and the 29th Year the Cycle begins again.

The Use of this Cycle is to find the Dominical Letter, which may be had from the following Table, when the Cycle of the Sun for a given Year is known; but this is found by adding 9 to the given Year, and dividing the Sum by 28; for the Remainder is the Cycle sought.

A Table of the Cycle *of the Sun, with the Dominical Letter answering to it.*

1 GF	5 BA	9 DC	13 FE	17 AG	21 CB	25 ED
2 E	6 G	10 B	14 D	18 F	22 A	26 C
3 D	7 F	11 A	15 C	19 E	23 G	27 B
4 C	8 E	12 G	16 B	20 D	24 F	28 A

Cycloid, or *Trochoid*, is a Curve; as ABC described by the given Point *a* in the Periphery of a Circle, while the Circle rolls along a right Line, as AC from the Point A, where the Curve begins, to the Point C, where it ends.



1. The Cycloid is a Curve of the mechanical kind; for the Relation of its Ordinates, (they being supposed

posed straight Lines,) and Abscissa's cannot be expressed in finite terms.

2. If PL be drawn parallel to AD, the Semi-Base of the Cycloid, then will PM be equal to BM, the Arch of the generating Circle; and so if the Arch BM be taken for an Abscis, and the right Line PM for a Semi-Ordinate, and BM $=x$, PM $=y$, the Nature of the Cycloid will be expressed by this Equation, $x=y$.

3. The Cycloidal Space, or the Space ABCD contain'd under the Curve of the Cycloid and the Base, is the Triple of the generating Circle.

4. The Length of any Arch AP, of a Cycloid, is equal to four times the versed Sine of half the Arch *a*H, of the generating Circle between the describing Point *a* and the Base of the Cycloid; whence the Length of the whole Cycloid is equal to four times the Diameter of the generating Circle.

Some of the *French* (amongst whom is Mr. *Pascal*) will have this Curve to be first taken notice of, and proposed to the Consideration of the Geometricans of those times by Father *Mersennus* in the Year 1615. But *Torricellius*, (in *Lib de Motu Gravium*, publish'd *Ann.* 1644.) says *Galilæo* mention'd it 45 Years before, *viz. Anno* 1599.——*Torricellius* first shew'd the cycloidal Space to be three times the generating Circle (tho' Mr. *Pascal* will have Mr. *Roberval* to be the first) —— The Solid generated by the Rotation of that Space about its Base to the circumscribing Cylinder to be as 5 to 8.— About the Tangent parallel to the Base, as 7 to 8.— About the Tangent parallel to the Axis, as 3 to 4.— He also says, that he could tell the Ratio of the Solid generated by the Rotation of the cycloidal Space about its Axis to the circumscribed Cylinder; but does not give it, no more than the Demonstration of the Ratio's aforesaid, except that of the first.— *Honoratus Fabry*, in *Synopsis Geom.* gives us a short Treatise of the Cycloid, wherein you have four ways of demonstrating the first of the Theorems above; as also the Demonstrations of all the rest, with several other Theorems about the Centres of Gravity of the cycloidal Space, *&c.* which he himself says, he found out before the Year 1658.

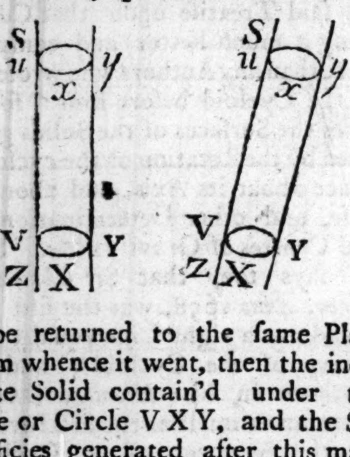
We learn from the Preface of Dr. *Wallis*'s Treatise of the Cycloid, that Mr. *Pascal*, in the Year 1658, proposed publickly at *Paris*, altho' without any Name, the two following Problems as a Challenge, to be solved by the Mathematicians of *Europe*, with a Reward of twenty Pistoles for so doing; which were to find the Dimension of any Segment of the Cycloid cut off by a right Line parallel to the Base, and the Solid generated by the Rotation of the same about the Axis, and about the Base of that Segment. Which set the Doctor upon writing the said Treatise upon that Curve, being a much better and compleat piece than any Authors who wrote upon the Cycloid before him: for he gives the Surfaces of the Solids generated by the Rotation of the cycloidal Space about its Axis, and about its Base, and other Determinations of the Centres of Gravity, *&c.* Here he says too, that Sir *Christopher Wren*, *Anno* 1658, was the first who found out a right Line equal to the Curve of the Cycloid; and Mr. *Huygens* in his *Horolog. Oscillat.* mentions himself as the first Inventor of the Segment of a Cycloidal Space, made by drawing a right Line parallel to the Base at the Distance of $\frac{1}{4}$ the Axis of the Curve from the Centre, being equal to a right-lin'd Space, *viz.* to a regular

Hexagon

Hexagon inſcribed in the generating Circle, whoſe Demonſtration is to be ſeen in *Wallis*'s ſaid Treatiſe.— There are ſeveral other Authors who ſpeak of the Cycloid, as Mr. *Farnat*, Mr. *Bernoulli*, here and there in the *Acta Eruditorum*, Mr. *de la Hire*, &c. too many to mention; and in the Memoirs of the Royal Academy of Sciences at *Paris*, *Ann.* 1706, you have the Doctrine of Cycloids, or rather Epicycloids, generated by Curves revolving upon themſelves.— This is the Curve that the Centre of Oſcillation of a Pendulum moving in, will deſcribe any Arches of it all in the ſame time, and a Body falling in it from any given Point above to another (not exactly) under it, will come to this Point, in a leſs time than in any other Curve, paſſing thro' thoſe two Points.

Cygnus, the *Swan*, a Conſtellation in the Northern Hemiſphere.

Cylinder. If any indefinite right Line SZ, being without the Plane of the Circle VXY, moves about the Circumference of that Circle always parallel to itſelf, until



it be returned to the ſame Place from whence it went, then the indefinite Solid contain'd under the Baſe or Circle VXY, and the Superficies generated after this manner by the right Line SZ, is called a *Cylinder*, and the ſaid Superficies is called the Superficies of it; and if the Line SZ be perpendicular to the Plane of the Baſe, the Cylinder is called a right one; but if not, an oblique or ſcalene one.

1. The Section of every Cylinder by a Plane oblique to its Baſe, is an Ellipſis.

2. The Superficies of a right Cylinder is equal to the Periphery of the Baſe, multiplied into the Length of its Side.

3. The Solidity of a Cylinder is equal to the Area of its Baſe, multiplied into its Altitude.

4. Cylinders of the ſame Baſe, and ſtanding between the ſame Parallels, are equal.

5. Every Cylinder is to a Spheroid inſcrib'd in it, as 3 to 2.

6. If the Altitudes of two right Cylinders be equal to the Diameters of their Baſes, thoſe Cylinders are to one another as the Cubes of the Diameters of their Baſes.

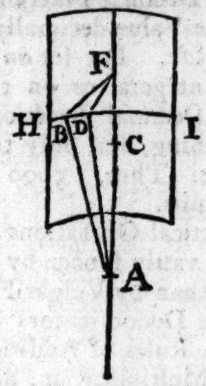
Cylindrical Speculum, is a Cylinder of poliſh'd Metal; being either convex or concave.

The Images of formous Objects, ſeen by the Reflexion of the Surface of a convex cylindrick Speculum, are render'd deformed; and *vice verſa* the Images of deformed Objects appear formous; ſo that a Figure altogether confuſed, ſeeming to be drawn without any manner of Intent, being placed horizontally near one of theſe Cylinders, will appear in the Surface of the Cylinder the Face of a Man, or any other formous Figure. But then the confuſed Figure muſt be firſt drawn according to Art.

If parallel Rays fall after ſuch a manner in the Superficies of a concave Cylinder, as to cut its Axis at right Angles, and their Inclination to the Speculum be leſs than ſixty Degrees; after the Reflection, they will be united in a right Line, parallel to the Axis, being at a Diſtance leſs than one fourth Part of the Diameter.

The Rays AB, AD, which, from the

the ſame Point A of the Axis, fall in the ſame Periphery H I of a con-



cave Cylinder, after the Reflexion, are united in the Point F, ſo far diſtant from C, the Centre of the Circle, in the Periphery whereof the Reflection is made, as the radiating Point A is diſtant from it.

Cymatium, a Member of Architecture; whereof there are two ſorts, *viz.* the *Doric* and the *Lesbic.* The *Doric* is a Member that has a Concavity leſs than a Semi-circular one, and a Projecture equal to half the Altitude. The *Lesbic* is both concave and convex, having the Projecture equal to half the Altitude.

Cynosura, a Conſtellation conſiſting of ſeven Stars, being otherwiſe called *Urſa Minor.*

Cypher, or nought, noted thus, (o); is that which being put before a Figure, ſignifies nothing, (unleſs in Decimals, where it augments, being put before, in the ſame proportion, as when put after Integers.) But after a Figure, it increaſes it by tens; and ſo on, *ad infinitum.*

D.

Dactylonomy, the Art of numbering on the Fingers.

Dado, a Term in Architecture, uſed by ſome Writers for a Dye, being the Part in the middle of the Pedeſtal of a Column, between its Baſe and the Cornice.

Daily Motion *of a Planet.* See *Diurnal Motion.*

Darkened Room. This is the ſame as *Camera Obſcura*; being a Room darkened all but in one little Hole, having a Convex-glaſs in it to tranſmit the Rays of outward Objects to a Piece of Paper, or white Cloth in the Room.

Dark Tent, by ſome Writers, is the Name of a ſmall portable *Camera Obſcura.*

Data, is the Term, in Mathematics for ſuch Things or Quantities as are given or known, in order to find out other things thereby, which are unknown.

Davis's Quadrant, the common *Sea-Quadrant*, or *Back-ſtaff.*

Day, is either *natural* or *artificial.*

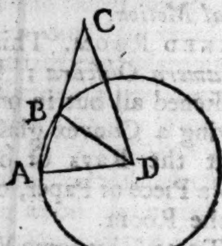
Day (Natural,) is the Space of Time determin'd by the Motion of the Sun round the Earth in twenty-four Hours, and begins at twelve at Night.

Day (Artificial,) is the Time between the Sun's Riſing and Setting. The Length of this varies in different Places of the Earth; for under the Equinoctial the Artificial Days are but twelve Hours long, and under the Poles they are half a Year.

The Natural Day is alſo called *Civil*, becauſe it is by divers Nations reckon'd divers ways. The *Babylonians* began to account their Day from the Sun-riſing: The *Jews* and *Athenians* from the Sun-ſetting, whom the *Italians* now follow, beginning their firſt Hour at Sun-ſet. The *Egyptians* began at Midnight, as we account the Aſtronomical Day; but the *Umbri* began at Noon.

Decagon,

DECAGON, in Geometry, is a plane Figure of ten Sides, and ten Angles; and if all the Sides are equal, and all the Angles, it is called a *regular Decagon*; and it may be inscrib'd in a Circle.



If A B be the Side of a regular Decagon inscrib'd in a Circle, and it be continued out to C, so that BC = A D, then will AB : B C :: BC : A C.

If r be the Radius of a Circle, then will $\sqrt{\frac{5}{4}r^2} - \frac{1}{2}r$, or $\sqrt{\frac{5-1}{2}}+r$ be the Side of a Decagon inscrib'd in that Circle.

If the Side of a regular Decagon be 1, the Area thereof will be nearly 8.69; whence as 1 to 8.69, so is nearly the Square of the Side of any given Decagon to the Area of that Decagon.

DECIMAL FRACTIONS, are such that have 10, 100, 1000, 10000, &c. for their Denominator; as, $\frac{5}{10}$, $\frac{6}{100}$, $\frac{37}{1000}$, $\frac{834}{1000}$, &c. and the Numerators, for Brevity and Conveniency sake, are commonly express'd by a Point, or Comma, set on the left Hand thereof, thus, .5 is $\frac{5}{10}$, .34 is $\frac{34}{100}$, and .346 is $\frac{346}{10000}$, the Denominators being omitted.

Regiomontanus was the first that used Decimal Fractions in the Construction of the Tables of Sines, about *A. D.* 1464.

As Cyphers set on the right Hand of Integers do increase the Value of them decimally, as 2, 20, 30, &c. so when set on the left Hand of Decimal Fractions, they decrease the Value decimally, as .5 .05 .005 &c. But set on the left Hand of Integers, or on the right Hand of Decimal Fractions, they signify nothing, but only to fill up void Places. Thus, .5000 or 0005. is but 5 Units.

Arithmetical Operations may be perform'd vastly sooner by Decimal Fractions than by Vulgar Fractions, because the Denominators being omitted, the Rules of Addition, Subtraction, Multiplication, and Division, are performed as in whole Numbers, regard being had to the Pointing, which is easy: Yet, by these, Operations will not always come out exactly true; but you may come as near the Truth as possible, by bringing out more Figures.

DECIMAL SCALES, are, in general, any Scales upon a square Rule, that are divided decimally, being Scales of Money, Weights, Measures, made from Tables bearing those Names, and serve readily, by Inspection only, to shew you the Decimal Fraction that properly belongs to any Part of Money, Weight, or Measure, &c.

DECLINATION (APPARENT,) is the Distance of the apparent Place of a Planet from the Equinoctial.

DECLINATION *of the Sun*, or any Star, or Point of the Heavens, is its Distance from the Equator, measur'd in the Arch of a great Circle, perpendicular to the Equator. R : S ☉'s Place :: S. greatest Declination. S. of his present Declination.

The greatest Declination of the Sun, or of the Ecliptic, was first, as we know of, observed by *Pytheas*, at *Massilia*, about three hundred and twenty-four Years before Christ; who

observing

observing that the Height of a Gnomon was to the Shadow of it, when the Sun was in the Meridian, as, 31951½ to 90000, from thence concluded the Sun's greatest Declination to be 23 deg. 52 min. 41 sec. And *Gassendus* found the Solstitial Shadow of the same Length, as it had been observed by *Pytheas*, near two thousand Years before: And so he concluded, that the Sun's greatest Declination, or that of the Ecliptic, is constant. But from a comparison of the several Observations concerning this matter, the Sun's greatest Declination is commonly accounted 23 deg. 30 min.

Declination *of the Sea-Compass*, or *of the Needle*, is its Variation from the true Meridian of any Place. See concerning this in Mr. *Lowthorp*'s Abridgment of the *Philosophical Transactions*, Vol. 2. chap. 4. pag. 607. *& seq.* And in Father *Noel*'s *Observationes Mathem. & Physic.* cap. 8. p. 108. *& seqq.*

Declination (True,) is the Distance of the true Place of a Planet from the Equator.

Declination *of a Wall*, or *Plane for Dials*, is an Arch of the Horizon, contained either between the Plane and the prime vertical Circle, if you reckon it from the East or West; or else between the Meridian and the Plane, if you account it from the North or South.

Declinatories, are Instruments contriv'd for taking the Declinations, Inclinations, and Reclinations of Planes; and are of several kinds. The best whereof, for taking the Declination, consists of a square Piece of Brass, or Wood, with a Limb accurately divided into Degrees, and every fifth Minute, if possible, having a horizontal Dial moving on the Centre, made for the Latitude of the Place it is to serve in, and which has a small bit of fine Brass fixed on its Meridian Line, like a fiducial Edge, to cut the Degrees of the Limb: For at any time when the Sun shines, by having the Hour of the Day, you may get the Declination of any Wall or Plane by this Instrument.

Declining Erect-Dials, are those whose Planes do stand perpendicular to the Horizon, and decline, that is, do not face directly the four Cardinal Points. See Erect *Declining* Dials.

Declining Erect-Planes. See *Erect Declining Planes.*

1. Because the Distance of the Sun from the Centre of the Earth is so vastly remote, that all Points of the Superficies of the Earth may be taken as if they were in the Centre, the Styles of all Dials may be conceived as Parts of the Axis of the Earth passing thro' the Centre of the Earth.

2. The Extremity of the Style of all Dials may be taken for the Centre of the Earth.

3. The Hour-Lines drawn upon all Dial-Planes, are the common Sections of Hour-Circles of the Sphere with the Dial-Planes.

The Equinoctial Circle upon all Dial-Planes, will be a straight Line, and the Parallels of Declination will be the Conic Sections.

Decussation, a Term in Optics, signifying the crossing of any two Lines, Rays, *&c.* when they meet in a Point, and then go on separately from one another.

Defences, in Fortification, are all sorts of Works that cover and defend the opposite Posts, as Flanks, Parapets, Casemates, *&c.* No Miner can be fixed to the Face of a Bastion before the opposite one be ruin'd, or till the Parapet of its Flank be beaten down, and the Cannon in all Parts that can fire upon that Place which is attack'd, are dismounted.

Deferent, in the old *Ptolemaic*

maic System, is an imaginary Circle, which, as it were, carries about the Body of a Planet, and is the same with the *Excentric*.

Deficient Hyperbola, is a Curve having but one Asymptote, and two Hyperbolic Legs running out infinitely next to the Asymptote contrary ways.

This Name is given to the Curves by Sir *Isaac Newton*, in his *Enumeratio Linearum tertii Ordinis:* There are six different Species of them which have no Diameters, expressed by the Equation $xyy + ey = -ax^3 + bx^2 + cx + d$. ax^3 being negative. When the Equation $ax^4 = bx^3 + cx^2 + dx + \frac{1}{4}ee$ has all its Roots real and unequal, the Curve will have an Oval joined to it. If the two middle Roots are equal, the Oval will join to the Legs, and they will cut one another in shape of a Noose. If these Roots are equal, the Nodus will be changed into a very acute Cusp or Point. If of three Roots, with the same Sign the two greatest are equal, the Oval will vanish into a Point. If any two Roots are imaginary, there will be only a pure Serpentine Hyperbola, without any oval Decussation, Cusp or conjugate Point; and when the Terms b and d are wanting, there will be the sixth Species.

There are also seven different Species of these Curves, each having one Diameter, expressed by the Equation aforesaid when the Term ey is wanting. According to the various Conditions of the Roots of the Equation $ax^3 = bx^2 + cx + d$, as to their Reality, Equality, their having the same Signs, or two of them being imaginary.

Deficient Numbers, are such, whose Parts, added together, make less than the Integer whereof they are the Parts; as 8, whose Parts being 1, 2, 4, make but 7; likewise 16, whose Parts 1, 2, 4, 8, make but 15.

Defile, in Fortification, is a straight narrow Line, or Passage, thro' which a Company of Horse or Foot can pass only in File, by making a small Front, so that the Enemy may take an opportunity to stop their March, and to charge them with so much the more Advantage, in regard that those in the Front and Rear cannot reciprocally come to the Relief of one another.

Definitions, are our first Conceptions of things, by means whereof, they are distinguished among themselves, and from whence, whatsoever things being conceived by them, the rest are deduced. There are two kinds of Definitions, *viz.* Nominal and Real.

Definition (Nominal,) is an Enumeration of such known Things that are sufficient for the distinguishing of any proposed Thing from others; as is that of a Square, if it be said to be a Quadrilateral, Equilateral, and Rectangular Figure.

Definition (Real,) is a distinct Notion of the Genesis of a Thing, that is, which expresses the manner how the thing can be done, or made; as is this Definition of a Circle, *viz.* That it is described by the Motion of a right Line about a fixed Point.

Deflection, is the Tendency of a Ship from her true Course, by reason of Currents, &c. which turn her out of her right way. But this Word, by Dr. *Hook* is applied to the Rays of Light; that is, Deflection of the Rays of Light is different both from Reflexion and Refraction, and is made towards the Surface of the opacous Body perpendicularly; and this is the same Property that Sir *Isaac Newton* calls *Inflection*.

Degree, is the three hundred and

and ſixtieth Part of the Circumference of a Circle. It is ſubdivided into ſixty Parts, called *Minutes*, and each of them again into ſixty more, called *Seconds*, &c.

DELPHINUS, the *Dolphin*, a Conſtellation in the Northern Hemiſphere, containing ten Stars.

DEMI-BASTION, is a Fortification, having only one Face, and one Flank.

DEMI-CANNON, *Loweſt*, the Name of a great Gun. (The ordinary ones are about ſix Inches Bore, five thouſand four hundred Pound Weight; ſome ten; ſome eleven Foot long; and carry a Shot of about thirty Pound Weight.) It carries point-blank an hundred and fifty-ſix Paces. Its Charge of Powder is fourteen Pound Weight. There are alſo two ſizes of Demi-Cannon above this, which are ſomething larger: As the

DEMI-CANNON *Ordinary*, which is ſix Inches and a half Bore, twelve Foot long, weighs five thouſand ſix hundred Pound. Its Charge of Powder is ſeventeen Pounds, eight Ounces, carries a Shot of ſix Inches one eighth in Diameter, whoſe Weight is thirty-two Pounds, and the Piece ſhoots point-blank an hundred and ſixty-two Paces.

DEMI-CANNON, *of the longeſt ſize*, is ſix Inches three fourths Bore, twelve Foot long, ſix thouſand Pounds Weight. Its Charge is eighteen Pounds of Powder, and the Piece ſhoots point-blank an hundred and eighty Paces.

DEMI-CROSS, is an Inſtrument uſed by the *Dutch* to take the Altitudes of the Celeſtial Bodies at Sea, and conſiſts of a Staff divided into a Line of Tangents, and a Croſs-piece, or Tranſom, and has three Vanes. But we do not uſe this Inſtrument, our Sea-Quadrant being better.

DEMI-CULVERING, a Piece of Ordnance. The common ſort of them are four Inches and a quarter Bore, two thouſand ſeven hundred Pounds Weight, ten Foot long, carries a Shot of ten Pounds eleven Ounces, is charged with ſeven Pounds four Ounces of Powder, and ſhoots point-blank an hundred and ſeventy-five Paces.

DEMI-CULVERING *of the leaſt ſize*, is four Inches and a quarter Bore, ten Foot long, two thouſand Pounds Weight. Its Charge is ſix Pounds four Ounces of Powder, it carries a Ball of four Inches Diameter, and of nine Pounds Weight, and its Level-range is an hundred and ſeventy-four Paces.

DEMI-CULVERING, *of the largeſt ſort*, is four Inches and three quarters Bore, ten Foot and one third long, three thouſand Pounds Weight. Its Charge of Powder is eight Pounds and eight Ounces, the Ball is four Inches and a half Diameter, weighs twelve Pounds eleven Ounces, and it ſhoots point-blank an hundred and ſeventy-eight Paces.

DEMIDITION, a Note in Muſic, being the ſame with *Tierce Minor*, See *Monochord*.

DEMI-GORGE, in Fortification, is half the Gorge or Entrance into the Baſtion, not taken directly from Angle to Angle, where the Baſtion joins to the Curtain, but from the Angle of the Flank to the Centre of the Baſtion, or Angle, the two Curtains would make, were they protracted to meet in the Baſtion.

DEMI-QUAVER, the laſt Note of Time in Muſic.

DEMONSTRATION, is the Reaſons that are laid down for making the Mind aſſent to the Truth or Falſhood of a thing propoſed.

DENEB, the ſame with *Cauda Lucida*, or *Lion's Tail*, a Star ſo called. Which ſee.

DENOMINATOR *of a Fraction*, is the Number or Letter below the Line

Line. Thus 4 and b are the Denominators of the Fractions, $\frac{3}{4}$ and $\frac{a}{b}$.

DENOMINATOR *of any Ratio*, is the Quotient arising from the Division of the Antecedent by the Consequent, as, 6 is the Denominator of the Ratio of 30 to 5, since 5) 30 (6; and this is also called the *Exponent of the Ratio.*

DENSITIES *of Bodies*, is their Thickness; and a Body is said to be denser, when it contains more Matter under the same Bulk than another Body.

The Densities of any two Bodies are in a Ratio compounded of the direct Ratio of their Quantities of Matter, and the reciprocal Ratio of their Bulks.

DENTICLES, are Ornaments in a Cornice, cut after the manner of Teeth. These are particularly affected in the Doric Order: and the square Member whereon they are cut, is called the *Denticule.*

DEPARTURE, in Navigation, is the Easting or Westing of a Ship, with regard to the Meridian it departed or sailed from; or it is the Difference of Longitude between the present Meridian the Ship is under, and that where the last Reckoning or Observation was made; and, in all Places, except under the Equator, it must be accounted according to the Number of Miles in a Degree of the Parallel the Ship is in.

The *Departure*, in *Plain* and *Mercator*'s Sailing, is always represented by the Base of a Right-Angle Triangle, where the Course is the Angle opposite to it, and the Distance the Hypotheneuse. In the *Plain* and *Mercator*'s *Chart*, as Radius to the Distance, so is the Sine of the Course to the Departure.

But this is erroneous, except in very small Distances; for if the Distance and Difference of Latitude be represented by the Hypotheneuse and Perpendicular of a right-angled plain Triangle, the Departure will not be the Base of that Triangle.

DEPRESSION *of the Pole.* So many Degrees as you sail or travel from the Poles towards the Zenith, you are said to depress the Pole, because it comes the same Number of Degrees lower, or nearer to the Horizon.

DESCANT, in Music, signifies the Art of composing in several Parts, and is threefold, *viz. Plain, Figurative*, and *Double.*

DESCANT (DOUBLE) is when the Parts are so contriv'd, that the Treble may be made the Bass; and, on the contrary, the Bass the Treble.

DESCANT (FIGURATIVE, *or* FLORID,) is that wherein Discords are concerned as well (tho' not so much) as Concords, and having all the Variety of Points, Figures, Syncopes, Diversities of Measures, and whatsoever else is capable of adorning the Composition.

DESCANT (PLAIN,) is the Ground-work or Foundation of the Musical Composition, and wholly consists in the ordinary placing of many Chords.

DESCENSION OBLIQUE. See *Oblique Descension.*

DESCENSION RIGHT. See *Right Descension.*

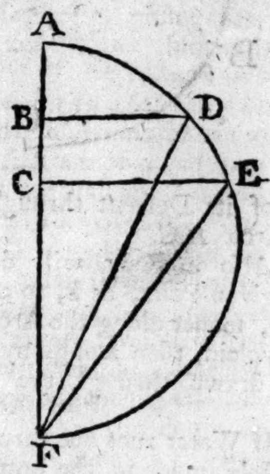
DESCENTS, in Fortification, are the Holes, Vaults, and hollow Places, made by undermining the Ground; as the *Counterscarp*, or *Covert-way*; so that a Descent into the Moat or Ditch, is a deep digging into the Earth of the Covert-way, in Figure of a Trench, of which the upper Part is cover'd with Madriers or Clays, against Fires, to secure the Passage into the Moat.

DESCENT *of heavy Bodies.* 1. If two Bodies descend perpendicularly from any unequal Heights near the Surface

Surface of the Earth, the Lengths of the Lines that they deſcribe, are in the duplicate Ratio of the Times or Velocities; and ſo the Velocities are as the Times.

But if Bodies deſcend pependicularly from any Heights whatſoever, then this Proportion will not hold.

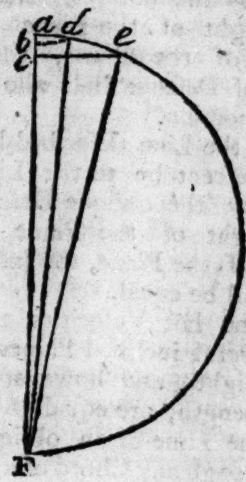
If A E F be a Semicircle, and F the Centre of the Earth, and a



Body falls from any Height A above the Surface of the Earth to the Places B, C, and the Lines B D, C E, are drawn; as alſo the Lines F D, F E, then the Times of its falling the Lengths A B, A C, will be expreſs'd by the trilineal Spaces F A D, F A E.

The Lengths that a Body near the Surface of the Earth deſcends in equal times, do increaſe according to the odd Numbers, 1, 3, 5, 7, 9, &c.

Hence, by way of Corollary, if a Body falls from the Point *a*, the ſmall Diſtances *a b*, *a c*, compar'd with *a* F the Semidiameter of the Earth, the trilineal Figures F *a d*, F *a e*, may be taken for right-angled Triangles, whoſe Areas will be, to one another, as the Lines *b d*, *c e*, ſince the Baſe *a* F is common, that is, as the very ſmall Arches *a d*, *a e*, which are equal to them. But theſe very ſmall Arches are in the ſubduplicate Ratio of their verſed



Sines *a b*, *a c*, that is, the Lines *a b*, *a c*, deſcribed by a deſcending Body, are in the duplicate Ratio of the Times, which is the Theorem firſt laid down.

2. All Bodies near the Surface of the Earth do deſcend perpendicularly at ſuch a rate, as that at the end of the firſt Second of Time they have deſcribed fixteen Feet one Inch.

3. The Velocity of a heavy Body deſcending in an inclin'd Plane at the end of any given time, is to the Velocity that it would acquire by deſcending perpendicularly in the ſame time, as the Altitude of the inclin'd Plane is to its Length.

4. The laſt Velocity acquired by the direct Deſcent, is to the laſt Velocity acquired in the ſame time by the oblique Deſcent, as the abſolute Gravity is to the relative Gravity of the deſcending Body.

5. The Line deſcrib'd by the direct Deſcent is to the Line deſcribed in the ſame time by the oblique Deſcent, as the Length of the

Plane to the perpendicular Height of the Plane.

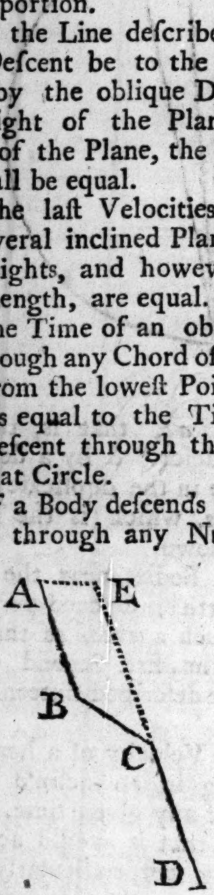
6. If the Line described by the direct Descent be to the Line described by the oblique Descent, as the Height of the Plane to the Length of the Plane, then the Times of Descent shall also be in that Proportion.

7. If the Line described by the direct Descent be to the Line described by the oblique Descent, as the Height of the Plane to the Length of the Plane, the last Velocities shall be equal.

8. The last Velocities acquir'd upon several inclined Planes of the same Heights, and however differing in Length, are equal.

9. The Time of an oblique Descent through any Chord of a Circle, drawn from the lowest Point of the Circle, is equal to the Time of a direct Descent through the Diameter of that Circle.

10. If a Body descends from the Point A through any Number of

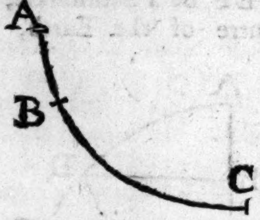


inclin'd Planes, A B, B C, C D, it will acquire the same Velocity at the Point D, in the End of its Fall, as though it fell from the Point E of equal Height with A, in one continued Plane E D.

11. The last acquir'd Velocities of a Body, descending to the lowest Point of a given Circle, through different Chords, shall be as those Chords.

In all these Theorems concerning the Descent of Bodies on inclined Planes, the Lengths of the Planes must be inconsiderable, with regard to the Semi-diameter of the Earth; for otherwise they are not true.

12. The Time of the Descent of a Body, through the Arch B C of a Semi-cycloid, is equal to the



Time of its Descent through any other Arch A C.

13. Also a Body will descend from a given Point, as B, to a given Point C, sooner along the Arch B C of a Cycloid, than along any other Curve, drawn through the Points B, C.

14. If Water runs out through a small Hole, made in the bottom of a parabolic Conoid, the Surface of the Water will descend equal Spaces in equal Times.

15. If a Body be thrown downwards in a resisting Medium, with such a Velocity as shall make the Resistance of the Medium equal to the Acceleration of Gravity, it will afterwards move on, or descend with an uniform Motion.

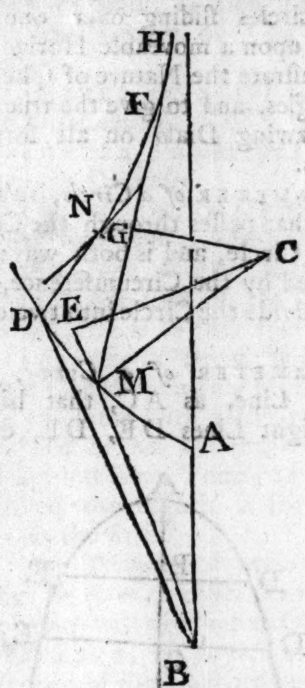
16. The Velocity of a Body descending by its own Weight, in a resisting Medium, is always less than that Velocity that produces the uniform Motion; but continually approaches to it.

Dew, are little Globules of Water, raised up from the Earth by Heat, which, for a while, swim up and down in the Air; and when several of them convene into Drops, by means of Cold, they then fall down again to the Earth.

Describent, a Term in Geometry, signifying a Line or Superficies, that by means of the Motion of it, a Superficies or Solid is describ'd.

Diacoustics, or Diaphonics, is the Consideration of the Properties of refracted Sound, as it passes through different Mediums. But the

Diacoustic Curve, or the *Caustic by Refraction*, is generated thus: If you imagine an infinite Number of Rays, B A, BM, BD,



&c. issuing from the same luminous Point B, to be refracted to or from the Perpendicular M C, by the given Curve A M D; and so, that C E, the Sines of the Angles of Incidence C M E be always to O G, the Sines of the refracted Angles O M G in a given Ratio, the Curve H F N, which touches all the refracted Rays A H, M F, D N, &c. is called the *Diacaustic*, or *Caustic by Refraction*.

Diadrome. This is the same with *Vibration*, or the Swing of a Pendulum.

Diagonal, is a straight Line drawn a-cross a Figure, from one Angle to another, and is called a *Diameter* by some. These are chiefly in quadrilateral Figures.

As the Lines A C, B D, are the Diagonals of the Parallelogram A B C D.

Every Diagonal, as A C, divides a Parallelogram into two equal Parts, or Triangles, A B C, A D C.

Two Diagonals A C, B D, of every Parallelogram, do mutually bissect each other, as in the Point E.

Diagonal Scale. See *Scales*.

Diagram, is a Scheme for the Designation, or Demonstration of any Figure.

Dial, or *Sun-Dial*, is the Description of Lines upon a given Plane, or on the given Superficies of any Body, after such a manner, that the Shadow of a Gnomon, or the Rays of the Sun, transmitted through some Hole, or reflected from a very little reflecting Substance, shall touch given Lines at a given Hour. And the manner of this Description is called *Dialing*.

The first Sun-Dial that was set up at *Rome*, was by *Papyrius Cursus*, about the 447th Year of the City, on the Temple of *Quirinus*; but it went not right. And about thirty Years afterwards, *M. Valerius Messala* brought another out of *Sicily*, and set it up upon a Pillar near the *Rostrum*. But this went not right neither, because not made for the Latitude of *Rome*. But about eleven

Years after there was one ſet up, that went more exact.

The Invention of Sun-Dials are by ſome attributed to *Anaximenes*; and by ſome to *Thales*. And *Vitruvius*, among the various kinds of Dials he mentions, ſays, That *Beroſus* the *Chaldean* invented one upon a reclining Plane, nearly parallel to the Equinoctial.

There are a great many Authors who have wrote upon Dialling. Some of which are,— *Vitruvius*, in his Architecture, *cap.* 4. & 7. *lib.* 9. — *Sebaſtian Munſter*, his *Horolographia.*— *John Dryander de Horologiorum varia Compoſitione.*— *Conrade Geſner*'s *Pandectæ.*— *Andrew Schoner*'s *Gnomonicæ.*— *Fred. Commandine de Horologiorum Deſcriptione.*— *Joan. Bapt. Benedictus de Gnomonum Umbrarumque Solarium Uſu.*— *Clavius*'s *Gnomonices de Horologiis*—— *Joannes Georgius Schomberg, Exegeſis Fundamentorum Gnomonicorum.* —— *Traité des Horologes Solaires*, by *Solomon de Caus.*—*Joan. Bapt. Trolta*'s *Praxis Horologiorum.*— *Deſargues*'s *Maniere Univerſelle pour poſer l'Eſſieu & placer les Heures & autres choſes aux Cadrans Solaires.*— *Ath. Kircher*'s *Ars magna Lucis & Umbræ.*— *Leybourn*'s Art of Dialing,—*Ozanam*'s Dialing.— *Hallum*'s *Explicatio Horologii in Horto Regio Londini.*—*Tractatus Horologiorum Joannis Mark.*— *La Gnomonique ou l'Art de Tracer les Cadrans, avec les Demonſtrations*, by Mr. *de la Hire.*— *Wells*'s Art of Shadows.

Dial (Cylindrical,) is a Dial upon the Convex Superficies of a Cylinder, where the Hour-Lines are Curves, drawn by means of the Sun's ſeveral Altitudes every Day that he enters into the Beginnings of the Signs; and the Hour of the Day is ſhewn by the Extremity of the Shadow of a Stile, ſtanding at right Angles to the Surface of the Cylinder at the top thereof.

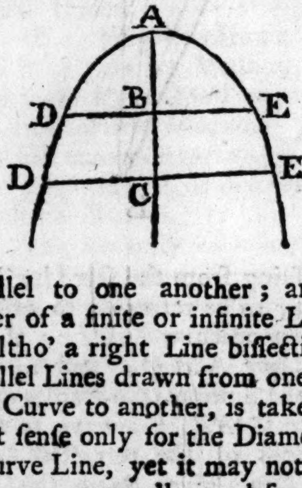
Dialling Globe, is an Inſtrument of Braſs, or Wood, with a Plane fitted to the Horizon, and an Index particularly contrived, to give a clear Demonſtration of that Art.

Dialling Lines, or *Scales*, are ſuch divided Lines, as being put on Rulers, or the Edges of Quadrants, and other ſuch like Inſtruments, ſerve to ſhorten the Buſineſs of Dialling.

Dialling Sphere, is an Inſtrument made of Braſs, with ſeveral Semi-circles ſliding over one another, upon a moveable Horizon, to demonſtrate the Nature of ſpherical Triangles, and to give the true Idea of drawing Dials on all ſorts of Planes.

Diameter *of a Circle*, is a right Line that paſſes through the Centre of the Circle, and is both ways terminated by the Circumference, and does divide the Circle into two equal Parts.

Diameter *of a Curve*, is a right Line, as A C, that biſſects the right Lines D E, D E, drawn



parallel to one another; and are either of a finite or infinite Length.

Altho' a right Line biſſecting all parallel Lines drawn from one Point of a Curve to another, is taken in a ſtrict ſenſe only for the Diameter of a Curve Line, yet it may not be amiſs more generally to define a Diameter, in ſaying, that it is that Line, whether Right or Curve, which biſſects all the Parallels drawn from one Point to another of a

Curve;

Curve; so that according to this, every Curve will have a Diameter. And thence Sir *Isaac Newton*'s Curves of the second Order, have all either a right-lin'd Diameter, or else the Curves of some one of the Conic Sections for Diameters. And many Geometrical Curves of the higher Orders, may also have for Diameters Curves of more inferiour ones, and that *ad infinitum*.

Diameter Conjugate *in the Ellipsis*. See *Conjugate Diameter*.

Diameter *of Gravity*, in any Surface or Solid, is that Line in which the Centre of Gravity is placed.

Diameter Principal. See *Principal Diameter*.

Diameter Transverse. See *Transverse Diameter*.

Diametrically Opposite, is when two things are the most opposite to one another that they can be; as one End of the Diameter of a Circle is to the other.

Diapason, a Term in Music, being a Chord including all Tones; and is the same with what we call an *Eighth*, or an *Octave*, because there are but seven Tones, or Notes, and then the eighth is the same again as the first.

If the Tension of two equal Strings be to each other, as 1 to 2, their Tones will produce an Octave.

Diapente, or *perfect Fifth*, is the second of the Concords making an Octave with the *Diatessaron*.

If the Tension of two equal Strings be as 3 to 2, then they will sound a *Diapente*.

Diaphanous Body, or *Medium*, is that through which the Rays of Light freely pass; as is Glass, Air, Water, the Humours of the Eye, &c.

Diastyle, is a sort of Edifice, where the Pillars stand at such a distance from one another, that three Diameters of their thickness are allow'd for the Intercolumnation.

Diatessaron, a Term in Music, being otherwise called a *perfect Fourth*, and signifies an Interval, consisting of one greater Tone, one lesser, and one greater Semi-Tone. If the Tension of two Strings of equal bigness be as 3 to 4, they will sound a *Diatessaron*.

Diatonic, a Term signifying the ordinary sort of Music, which proceeds by different Tones, either in ascending or descending. It contains only the two greater and lesser Tones, and the greater Semi-Tone.

Diesis in Music, is the Division of a Tone below a Semi-Tone, or an Interval composed of a lesser and imperfect *Semi-Tone*. So that when Semi-Tones are placed where there ought to be Tones, or when a Tone is set where there should be only a Semi-Tone, this is called *Diesis*.

Diesis (Enharmonical,) is the difference between the greater and lesser Semi-Tones.

Difference, is the Excess whereby one Magnitude exceeds another.

Difference *of Ascension*. See *Ascensional Difference*.

Difference *of Longitude of two Places of the Earth*, is an Arch of the Equator contained between the Meridians of those two Places.

Differential *of any Quantity* amounts to the same as the Fluxion of that Quantity. This Word is not used by us.

Diffusion, commonly signifies the dispersing of the subtle Effluvia of Bodies into a kind of Atmosphere all round them.

Digit, in Astronomy, is the twelfth Part of the Diameter of the Sun or Moon, and is used to express the Quantity of an Eclipse.

Digits, or *Monades*, a Term in Arith-

Arithmetic, which signifies any Integer under 10; as 1, 2, 3, 4, 5, 6, 7, 8, 9.

DILATATION, signifies a thing taking up more Space than it did before.

DIMENSION, in Geometry, is either Length, Breadth, or Thickness; as, a Line hath one Dimension, *viz.* Length; a Superficies two, *viz.* Length and Breadth; and a Body or Solid has three, *viz.* Length, Breadth, and Thickness. This Word is also used with regard to the Powers of the Roots of an Equation, which are called the *Dimensions of that Root:* As in a cubic Equation the highest Power has three *Dimensions.*

DIMETIENT. The same with *Diameter.*

DIMINISHED ANGLE, a Term in Fortification. See *Angle.*

DIMINUTION, in Music, is nothing else but the abating something of the full Value or Quantity of any note.

DIOPTER, the same with the Index or Alhidada of an Astrolabe, or such-like Instrument.

DIOPTRICS, is the Science of refracted Vision; or it is that Part of Optics, which treats of the different Refractions of Light, in its Passage through different Mediums, as Air, Water, Glass, &c.

Dioptrics is one of the most useful and pleasant Sciences that Man ever had to do with, restoring even the Blind to Sight with very little ease, and at a very small expence, bringing vastly remote Objects, as well as very small ones, within the reach of the Eye, affording both Pleasure and Amazement, which otherwise would never have been so much as thought of; and all this by means of the wonderful attractive Power in Glass and Water, causing the Rays of Light in their Passage thro' them to alter their Course, according to the different Surfaces (Curve or right-lin'd, Concave or Convex, Spherical, or otherwise, and these greater or lesser) of the Glass or Water; by which means the Objects seen thro' them, do, in appearance, alter their Magnitude, Distance and Situation.

The Ancients have treated of direct and reflected Vision; but what we have of reflected Vision, is very lame and imperfect. *Joannes Baptista Porta*, in a Treatise of Refraction, in nine Books, has endeavoured at rendring this Doctrine more perfect; but without any tolerable Success. The first who wrote tolerably well upon Dioptrics, was *Kepler*, who has demonstrated the Properties of spherical Lens's very accurately, in a Treatise first published *anno* 1611.——After *Kepler*, *Gallilæo* has given something of this Doctrine in his Letters; as also the Examination of the Preface of *Johannes Pena* upon *Euclid*'s Optics, concerning the Use of Optics in Astronomy.—— *Descartes* also published a Treatise of Dioptrics, commonly annexed to his Principles of Philosophy, wherein is the true Law of Refraction found out by *Snell*; but the Name of the Inventor suppress'd, and the true Manner of Vision more distinctly explain'd than by any before him. Herein is laid down the Properties of elliptical and hyperbolical Glasses, and the Praxis of grinding Glasses.——Dr. *Barrow* has treated of *Dioptrics* in a most elegant manner, altho' somewhat too briefly, in his *Optical Lectures*, read formerly at *Cambridge*.— There is Mr. *Huygens*'s *Dioptrics*, a perfect Work of its kind.—— *Molyneux*'s *Dioptrics*, a heavy dull Piece, altho' it may be useful to some.—— Mr. *Hartsoeker*'s *French* Essay of *Dioptrics*.— Father *Cherubin*'s *Dioptrique Oculaire*, and *La Vision parfaite*.—— Dr. *David Gregory*'s Elements of Dioptrics.— *Traber*'s *Nervus Opticus*.

cus.—*Zahn*'s *Oculus Artificialis Teledioptricus.*— Dr. *Smith*'s Optics, a compleat Work of its kind.——*Wolfius*'s Dioptrics, contain'd in his *Elementa Matheseos Universalis.*

Dipping Needle. If a magnetical Needle be duly poised about an horizontal Axis, it will have a Direction of Altitude above the Horizon, besides its Direction towards the North, in an horizontal Position, always pointing to a determinate Degree of Altitude or Elevation, above the Horizon, in this or that Place respectively. It is now called a *Dipping Needle*. And Mr. *Whiston* of late has endeavour'd to discover the Longitude by it.

Dipteron, in Architecture, a Name which the Ancients attributed to those Temples, which were encompassed with a double Row of Pillars, making two Porticos, which they called *Wings*; but we commonly call them *Isles*.

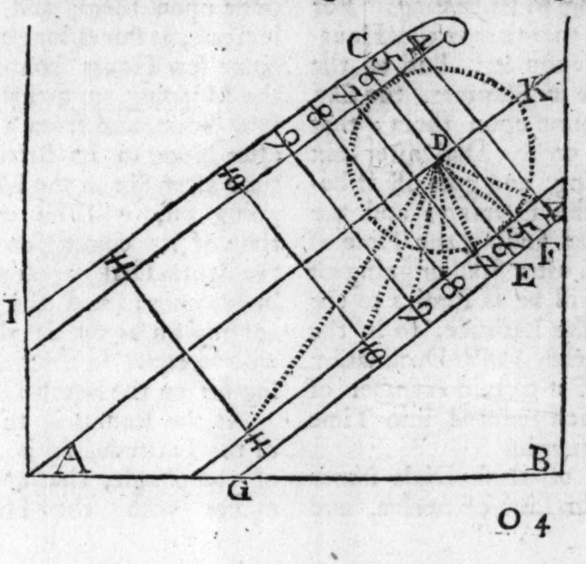
Direct, in Astronomy. A Planet is said to be direct when it goes forward by its proper Motion in the Zodiac, according to the Succession of the Signs; or when it appears so to do to an Observer standing upon the Earth.

Direct Erect East and West Dials, are Dials drawn upon Planes, that directly face the East and West, or are parallel to the Meridian of the Place.

These Dials shew the Hour but from Sun-rising to Noon, or from Noon to the Sun-setting; and the Hour-Lines are all parallel to one another, and at Distances from the Hour-Line of six, that are equal to the natural Tangents of the Degrees in the several Hours.

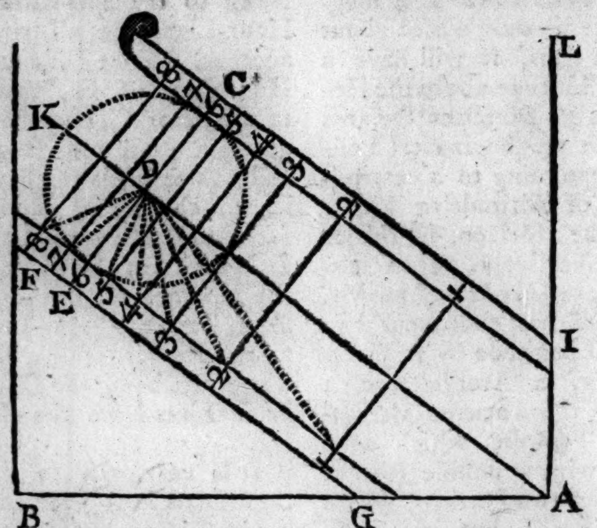
In these Dials the Style is parallel to the Plane, stands upon the Hour-Line of Six, and its Height or Distance from the Plane is equal to the Distance of the Hour-Line of Nine, from the Hour-Line of Six, or to the Radius of the said Line of Tangents, being the Distances of the Hour-Lines from the Hour-Line of Six.

It is very easy to draw one of these Dials for a given Latitude: For having drawn the horizontal Line AB, and the right Line AK from any Point A thereof, making the Angle BAK equal to the Complement of the Latitude, with the Radius DE describe a Circle, and thro' the Centre D draw EC perpendicular to AK; so that the Circle may be divided into Quadrants, and divide each of the Quadrants into six equal Parts, and



 from

from the Centre D to the Points of Division draw the right Lines D 4, D 5, D 6, D 7, D 8, D 9, D 10, D 11, and thro' the Points 4, 5, 6, 7, 8, 9, 10, 11; draw Parallels 4, 4. 5, 5. 6, 6. &c. to E C; and these Parallels will be the Hour-Lines. A West Dial is drawn after the same manner as appears in *Fig.* 2. representing a West Dial.



Direct Erect South, or North Dials, are Dials drawn upon Planes that directly face the South or North, or are parallel to the prime vertical Circle, or to the vertical Circle cutting the Horizon in the East and West Points.

The Sun shines upon the South Dial of this kind, at the time of the Equinox, just twelve Hours, or from its Rising to its Setting. For which reason there are twelve Hour-Lines drawn upon it: But as the Days increase in Summer, the Sun shines a less time upon them; that is, he comes on the Dial after Six in the Morning, and goes off it before Six in the Evening; and the Proportion for finding the Time of its coming on after Six, or going off before Six, will be as Radius to the Tangent of the Latitude, so is the Tangent of the Sun's Declination to the Sine of a certain Number of Degrees, which reduced into Time will be that sought.

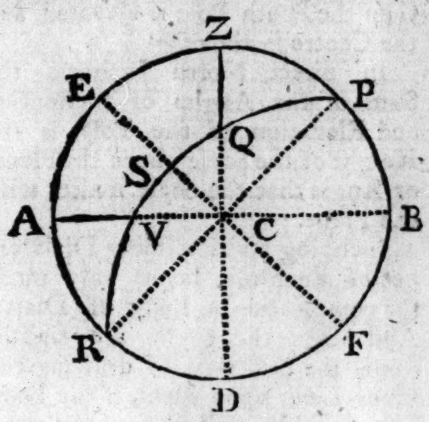
The Style of these Dials stands upon the Hour-Line of twelve, and makes an Angle with the same, equal to the Complement of the Elevation of the Pole; that of the South Dial facing downwards, and that of the North upwards.

North Dials are but of little use; for from the time of the Autumnal Equinox to the Vernal one, the Sun does not shine upon them; but at the Vernal Equinox it begins to shine upon them, and as the Days increase, it shines longer and longer. Some few Hours from its Rising in the Morning, to a certain time before Noon, and from a certain time after Noon to its Setting, and the time after Six in the Morning of its going off, will be equal to the time of its coming on after Six in the South-Dial, or any given Day in Summer; and the time of its coming on again in the Afternoon will be equal to the time of its going off on the South-Dial.

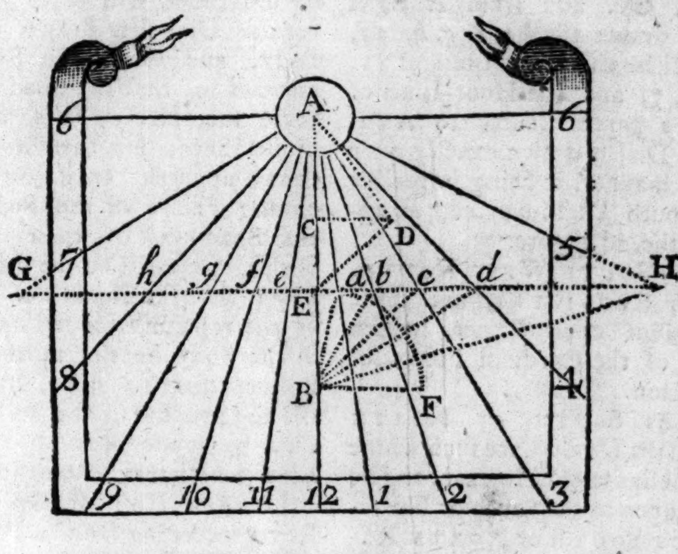
As the Radius is to the Co-sine of the Latitude, so is the Tangent of the Angle, that any Hour-Line makes with the Hour-Line of twelve

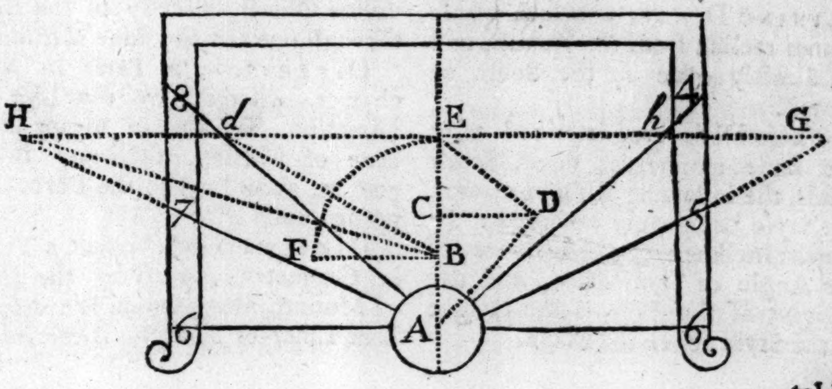
twelve, to the Tangent of the plane Angle, that that Hour-Line makes with the Hour-Line of twelve.

If A B be the Horizon, E F the Equinoctial, D Z the prime Vertical, A Z P D the Meridian, P R the Hour-Line of Six, and Axis of the World in a given Latitude B P, and R S P be any Hour-Circle; then in the spherical Triangle Q Z P right-angled at Z, the Side Z Q will represent the right-lin'd Angle made by that Hour-Line, with the upright Meridian upon the Plane of a South or North Dial; so that to find the several Hour-Angles, you have given in that spherical Triangle, the Angle Z P V, and the Side Z P, the Complement of the Latitude, to find the Side Z Q.



South or North Dials may be drawn geometrically, thus: Draw the upright Line A B for the Meridian or Hour-Line of 12, and





taking

taking any convenient Distance AC, raise the indefinite Perpendicular CD, and make the Angle CAD equal to the Complement of the Latitude of the Place the Dial is made for; and at D make the Angle EDC equal to CAD, and thro' E draw the right Line GH cutting the Line A 12 at right Angles. Make EB = ED, and with this as a Radius describe a Quadrant of a Circle, and divide the same into six equal Parts, and thro' the Points of Division draw the right Lines B*a*, B*b*, B*c*, B*d*, &c. to cut the Line GH; then right Lines drawn from A thro' *a*, *b*, *c*, *d*, &c. will be the Hour-Lines of 1, 2, 3, 4, 5. And if E*e*, E*f*, E*g*, E*h*, be taken respectively equal to E*a*, E*b*, E*c*, &c. and from A right Lines be drawn thro' *e*, *f*, *g*, *h*, &c. these will be the Hour-Lines of 11, 10, 9, 8, 7, and the Hour-Line of 6 will be perpendicular to A 12. A North Dial is drawn exactly after the same manner, it being in reality only a South Dial inverted, as appears in the 2d Figure.

Direct South, West, North, or East Recliners, are those Dials drawn upon Planes, which face any of the Cardinal Points of the Horizon.

Direct South or North Inclining Dials, are such whose Planes incline to the Horizon, and lie directly open to the South or North.

Direct South or North Reclining Dials, are such whose Planes recline from the Zenith, and lie directly open to the South or North.

These Dials are described after the same manner as direct South Dials, the following Rule in placing the Style being only observed: In South Incliners the Difference of the Angle of Inclination, and the Height of the Pole is the Height of the Style above the Plane.

If the Height of the Pole be greater than the Angle of Inclination, then the North Pole is elevated, and the Centre is below.

If the Height of the Pole be lesser than the Angle of Inclination, then the South Pole is elevated, and the Centre is above.

In direct North Incliners the Sum of the Angles of Inclination and Elevation of the Pole, is the Height of the Style above the Plane, or Angle that the Style makes with the Plane.

Inclining and Reclining Dials are not of much use, being only made for compleating a Body of Dials: And after the Styles are rightly fixed, the best way of drawing the Hour-Lines upon them, if the Body be moveable, will be to get a good regular Dial first drawn upon the Body, and when the Sun shines move it so, that the Shadow of the Style successively falls upon the Hour-Lines; for then if Lines are drawn upon the Inclining and Reclining Planes of the Body, along the Shadows of their respective Styles, they will be the same Hour-Lines that the Shadow of the Style of the regular Dial fell upon. But if the Body be not moveable, the Business must be done, by waiting till the Shadow of the Style of the Dial has gone over all the Hour-Lines, which may be done in one Day.

Direct Ray, in Optics, is the Ray proceeding from a Point of a visible Object, directly to the Eye, through one and the same Medium.

Direction, a Term in Mechanics, wherein, by the Line of Direction, is always meant the Line of Motion, that any Body goes in, according to the Force impressed upon it.

Directrix, or *Dirigent*, a Term in Geometry, signifying the Line of Motion, along which the describent Line, or Surface, is carried in the

the Genesis of any Plane or solid Figure.

Discontinual Proportion. See *Discrete Proportion.*

Discords, in Music, are certain Intervals of Sounds, which being heard at the same time are unpleasant to the Ear; and these are the second, fourth, and seventh, with their Octaves, that is, all Intervals, but those few that exactly terminate the Concords, are Discords.

Notwithstanding Discords sound unpleasant, when heard by themselves, yet being artfully mixed with Concords, they make the best Music: And of all the Discords a second is the most unpleasant.

Discrete (or *Disjunct*) Proportion, is when the Ratio of two or more Pairs of Numbers or Quantities is the same, but not continual, that is, when the Ratio of the Consequent of one Pair of Numbers, or Quantities, to the Antecedent of the next Pair, is not the same, as of the Antecedent of one Pair to its Consequent; as 3 : 6 :: 8 : 16. are discrete Proportionals; because the Ratio of 3 to 6 is equal to the Ratio of 8 to 16. But the Ratio of 3 to 6, or 8 to 16, is not the same as of 6 to 8.

Discrete Quantity, is such as is not continuous, and joined together; as Numbers, whose Parts being distinct Units cannot be united into one *Continuum*; for in a *Continuum* there are no actual determinate Parts before Division; but they are potentially infinite.

Disdiapason, a Term in Music, being a double eighth or fifteenth.

Disk *of the Moon, or any Planet*, is the Circle made by cutting it thro' the Centre by a Plane perpendicular to a Line drawn from the Earth or Sun.

Dispart, a Term in Gunnery, signifying the setting a Mark upon the Muzzle Ring of a Piece of Ordnance, or thereabouts, so that a Sight-line taken upon the top of the Base-Rings, against the Touch-hole, by the Mark set on or near the Muzzle, may be parallel to the Axis of the Concavity of the Piece.

This is commonly done, by taking the two Diameters of the Base-Ring, and of the Place where the Dispart is to stand, and dividing the Difference between them into two equal Parts, one of which will be the Length of the Dispart, which is set on the Gun with Wax or Pitch.

Disseminate Vacuum. See *Vacuum.*

Dissonance, in Music, is a disagreeable Interval between two Tones, which, being continued together, offend the Ear.

Distance, in Navigation, is the Number of Degrees or Leagues, &c. that a Ship has sailed from any given Place or Point.

Distance *of the Eye*, in Perspective, is a Line drawn from the Foot of the Altitude of the Eye to the Point, where a Line drawn at right Angles to it will intersect the Object.

Distance *of the Bastions*, in Fortification, is the Side of the exterior Polygon.

Distinct Base, in Optics, is that Distance from the Pole of a Convex Glass, in which Objects beheld through it appear distinctly, and well defined, and is what is otherwise called the *Focus.*

Distinct Vision. See *Vision.*

Ditone, *a double Tone*, or *the greater Third*, is an Interval in Music, which comprehends two Tones.

If the Tension of two equal Strings be as 4 to 5, or as 5 to 6, they will sound a Ditone, or a Semi-ditone.

Divergent Point. See *Vertical Focus.*

Divergent (or *Diverging*) Rays, in Optics, are those Rays, that,

that, iſſuing from a Point of a viſible Object, are diſperſed, and continually depart from one another, according as they are removed from the Object.

Diverging Parabola. See *Parabola Diverging*.

Dividend, in Arithmetic, is the Number that is to be divided into equal Parts by another Number.

Divisibility, is that Diſpoſition of a Body, whereby it is conceived to have Parts, into which it may actually or mentally be divided.

Body is diviſible *in infinitum*; that is, you cannot conceive any Part of its Extenſion, ever ſo ſmall, but that ſtill there may be a ſmaller.

There are no ſuch Things as Parts infinitely ſmall; but yet the Subtility of the Parts of ſeveral Bodies is ſuch, that they very much ſurpaſs our Conception. And there are innumerable Inſtances in Nature of ſuch Parts, that are actually ſeparated one from another.

1. Mr. *Boyle* mentions a ſilken Thread, that was three hundred Yards long, which weighed but two Grains and a half.

2. He alſo ſaid, that fifty ſquare Inches of Leaf Gold weighed but one Grain. Now, if an Inch in Length be divided into two hundred Parts, the Eye may diſtinguiſh them all. Therefore, in one ſquare Inch there are forty thouſand viſible Parts; and in one Grain of Gold there are two Millions of ſuch Parts; which may be yet further divided.

3. A whole Ounce of Silver may be gilt with eight Grains of Gold, which is afterwards drawn out into a Wire of 1300 Foot long.

4. In odoriferous Bodies we can ſtill perceive a greater Subtility of Parts, which are ſeparated from one another, for ſeveral Bodies ſcarce loſe any ſenſible Part of their Weight in a long time, and yet continually fill a very large Space with odoriferous Particles.

Dr. *Keil* in his *Vera Phyſica*, Lect. 5. has been at the pains to calculate the Magnitude of a Particle of *Aſſa Fœtida*, which will be $\frac{57}{100000000000000000}$ of a Cubic Inch. And in the ſame Lecture he ſhews, that the Particles of the Blood in the Animalculæ, that are obſerved in Fluids by means of Microſcopes, muſt be leſs than that Part of a Cubic Inch which is expreſſed by a Fraction, whoſe Numerator is 8, and Denominator Unity with thirty Cyphers after it.

Division, one of the four Rules of Arithmetic, is the finding of a Number or Quantity ſuch, from two given Numbers or Quantities, that it ſhall be to one of the Numbers or Quantities, as Unity is to the other.

Division *of Numbers*, is only a compendious Subtraction; for ſince the Diviſor is ſo many times contained in the Dividend as there are Units in the Quotient, therefore continually ſubtracting the Diviſor from the Dividend, and accounting an Unit for each Time, the Sum of theſe Units is the Quotient.

1. One whole Number may be divided by another, by the following Rule: 1. Set a Point under the laſt of the Left-hand Places in the Dividend, out of which the Diviſor may be taken, and the Number of Places in the Dividend to the right of that Point incluſive gives the Number of Places of the Quotient; as if 1096825 were to be divided by 365. I ſet a Point under 6, and not 9; becauſe I cannot get 365 in 109. But in 1096, I may: And ſo the Quotient will conſiſt of four Figures. Hence there are three Figures 825 to the right of 6. 2. Try how often you can take the Diviſor 365 out of the firſt

first Part (1096) of the Dividend, which will be always less than ten times; and set the Number of times 3 in the Quotient, then multiply the Divisor thereby and subtract the Product 1095 out of the said Part 1096 of the Dividend, and set down the Remainder. 3. To the right of the Remainder set down the next Figure of the Dividend, from which take the Divisor as often as you can, setting down the Number of times in the Quotient, multiply the Divisor thereby and subduct the Product as before; and in this manner the Operation must be repeated to the end. 4. If the Divisor has Cyphers towards the Right-hand, cut off so many of the Right-hand Places of the Dividend as there are Cyphers in the Divisor, which annex to the Remainder when the Operation is finish'd.

2. Division of Decimal Fractions is the same, as in whole Numbers; but in finding out the true value of the Quotient, it is to be observed, that the Divisor being placed under the Dividual, the Figure answering it in the Quotient, must always be in a like Place with that Figure in the Dividend, which is over the Unit's Place of the Divisor; as if .0006528 were to be divided by .032. If .032 be placed under the first Dividual .00065, it appears thus, $\begin{array}{l}.0006528\\ .032\end{array}$. And the second Decimal Place in the Dividend, stands over the Place of Units in the Divisor; wherefore the first Figure 2 in the Quotient, must be in the second Decimal Place, and so the first Place is to be supply'd with a Cypher. See the Operation

$$\begin{array}{l} .032)\ .0006528\ (\ .0204 \\ 64 \\ \hline 128 \\ 128 \\ \hline 0 \end{array}$$

which is always perform'd without the Cyphers prefix'd to the Divisor and Dividend. If the Dividend has not significant Figures enough for to be divided by the Divisor, or if after the Division there be a Remainder, you may proceed to what Degree of Exactness you please, by annexing Cyphers to the Right-hand. — The Value of the Quotient after the Division is ended may be found by this Rule, as well as that before laid down. Consider how many Decimal Places there are in the Dividend, for so many must there be in the Quotient as the Dividend has more than the Divisor, and to cause this, a Cypher must oftentimes be prefix'd.

3. Vulgar Fractions are divided by the following Rule. Multiply the Numerator of the Dividend by the Denominator of the Divisor, and the Product is the Numerator of the fractional Quotient; and then multiply the Denominator of the Dividend by the Numerator of the Divisor, and the Product is the Denominator of the fractional Quotient.

To divide one Fraction by another, is by the Nature of Division to find how often the Divisor, that is, how often such a part of its Numerator as is express'd by the Denominator, is contain'd in the Dividend. In dividing any proper Fractions by one another, the Dividend being really the Product of the Divisor, and Quotient multiplied together, will be less than either of them, when the Quotient is a proper Fraction; or when any Fraction or whole Number is divided by a proper Fraction, the Quotient will always be greater than the Dividend.

4. Algebraic Division is performed by taking to pieces what has been compounded by Multiplication; as *ab* divided by *a* gives *b* for

for the Quotient; $6ab$ divided by $3b$, gives $2a$ for the Quotient; $16abc^3$ divided by $2ac$, gives $8bcc$ for the Quotient. But if the Quantity to be divided cannot be thus resolved by Division, it is enough, when both the Quantities are not Fractions, to set down the Divisor underneath, with a short Line between them; thus ab divided by c, will be $\frac{ab}{c}$. But when the Quantities are Fractions, they are divided like vulgar Fractions, as $\frac{a}{b}$ divided by $\frac{c}{d}$, will be $\frac{ad}{bc}$. If a Quantity to be divided be compounded of several Terms, its Division is performed by applying each of its Terms to the Divisor; as $aa+4ax-xx$ divided by a gives $a+4x-\frac{xx}{a}$. But when the Divisor also consists of several Terms, the Division is performed as in Numbers, in order to rightly perform which, the Terms of the Quantity to be divided, as well as of the Dividend, ought to be orderly disposed according to the Dimensions of some Letter, which is thought most convenient for this purpose; so that those stand in the first Place in which that Letter is of the most Dimensions; and those in the second, in which the Dimensions of it are nearest to the greatest; and so on to those Terms which are not at all multiplied by that Letter, and so are to be last of all; as if $a^3+2aac-aab-3abc+bbc$, were to be divided by $a-b$; it would stand thus:

$$
a-b\,\Big)\; \begin{array}{l} +2aac \\ a^3-aab \end{array} -3abc+bbc\;\Big(\; aa+2ac-bc
$$

$$
\begin{array}{l}
a^3-aab \\ \hline
0+2aac-3abc \\
2aac-2abc \\ \hline
0-abc+bbc \\
-abc+bbc \\ \hline
0 \quad 0
\end{array}
$$

$$
\text{Or thus } -b+a\,\Big)\; c\,bb \begin{array}{l} -3ac \\ -aa \end{array} b \begin{array}{l} +a^3 \\ +2aac \end{array} \Big(\; -cb \begin{array}{l} +2ac \\ +aa \end{array}
$$

$$
\begin{array}{l}
c\,bb-acb \\ \hline
0-2acc \\
-aa \;\; b \begin{array}{l} +a^3 \\ +2aac \end{array} \\
\begin{array}{l} -2ac \\ -aa \end{array} b \begin{array}{l} +2aac \\ +a^3 \end{array} \\ \hline
0 \qquad 0
\end{array}
$$

Some begin Algebraic Division from the last Terms; but it comes to the same thing, if the Division be performed successively. Note also, when an affirmative Quantity is divided by an affirmative one, the Quotient will be an affirmative one: so also, when a negative Quantity is divided by a negative one, the Quotient will be an affirmative Quantity. And when an affirmative Quantity is divided by a negative

tive one, or a negative Quantity by an affirmative Quantity, the Quotient will be a negative Quantity.

DIVISION *of Proportion.* If four Quantities be proportional, as *a* : *b* : : *c* : *d*. then the Assumption of the Difference between the Antecedents (*a*—*b*, or *b*—*a*) to either the Antecedent (*a*,) or Consequent (*b*,) of the first Ratio (*a* to *b*;) and the Difference between the Antecedents (*c*—*d*, or *d*—*c*) to either the Antecedent (*b*,) or Consequent (*d*) of the second Ratio *c* to *d*, is called *Division of Proportion.*

DIVISOR, in Arithmetic, is the Number that divides another, or that which shews into how many Parts the Dividend is to be divided.

DIURNAL ARCH, is that Arch that the Sun, Moon, or Stars describe between their Rising and Setting.

DIURNAL MOTION *of a Planet,* is so many Degrees and Minutes, &c. as any Planet moves in twenty-four Hours. And the Motion of the Earth about its Axis is called its *Diurnal Motion.*

DIURNAL PARALLAX. See *Parallax.*

DODECAGON, a regular Polygon, consisting of twelve equal Sides and Angles; and in Fortification it is a Place with twelve Bastions.

If the Radius of a Circle, in which the *Dodecagon* is inscribed, be $=1$, then the Side of the *Dodecagon* will be nearly .654. And as 1 is to the Square of the Side of any given *Dodecagon*, so is 2.51956 to the Area of it nearly.

DODECAHEDRON, is one of the Platonic Bodies, or five regular Solids, and is contained under twelve equal and regular Pentagons.

The Solidity of a *Dodecahedron* is found by multiplying the Area of one of the Pentagonal Faces of it by 12; and then this latter Product by $\frac{1}{3}$, of the Distance of that Face from the Centre of the *Dodecahedron*, which is the same as the Centre of the circumscribing Sphere.

The Side of a *Dodecahedron*, inscribed in a Sphere, is the greater Part of the Side of a Cube, inscribed in that Sphere, cut into extream and mean Proportion.

If the Diameter of the Sphere be 10000, the Side of a *Dodecahedron*, inscribed in it, will be .35682 nearly.

All *Dodecahedrons* are similar, and are to one another as the Cubes of their Sides; and their Surfaces are also similar, and therefore they are as the Squares of their Sides; whence, as .509282 is to 10.51462, so is the Square of the Side of any *Dodecahedron* to the Superficies thereof; and as .3637 to 2.78516, so is the Cube of the Side of any *Dodecahedron* to the Solidity of it.

DODECATEMORY. The twelve Signs of the Zodiac, *Aries*, *Taurus*, &c. are so called, because each of them is the twelfth Part of the Zodiac.

DOME, is a round, vaulted, or arched Roof of a Church, or any great Building.

DOMINICAL LETTER, one of the first seven Letters of the Alphabet; wherewith the Sundays are mark'd through the Year in the Almanack.

If any given Year be added to one fourth Part of it, omitting Fractions, and you add 4 to the Sum, and divide the whole by 7, and then subtract 7 from the Remainder, this last Remainder shews the Order of the Dominical Letter for that Year in the Alphabet: For Example;

In the Year	1725
The fourth Part is omitting Fractions,	431
To both which add	4
The Sum is	2106

Which

Which divided by 7, leaves 4, and 4 taken from 7, leaves 3; wherefore the Dominical Letter is C for that Year.

Donjon, in Fortification, commonly signifies a large Tower, or Redoubt of a Fortress; from whence the Garrison may retreat in case of Necessity, and capitulate with good Advantage.

Doric Order *of Architecture*, is the second Order, and the most agreeable to Nature, having no Ornaments on its Base, nor its Capital. Its Column is eight Diameters high, and its Freeze is divided between Triglyphs and Metopes.

This Order, which represents Solidity, ought not to be used but in great and massy Buildings, as the Outsides of Churches and public Places.

Double Descant. See *Descant*.

Double Horizontal Dial, is a horizontal Dial of Mr. *Oughtred*'s, with a double Gnomon; one to shew the Hour on the outward Circle, and the other to shew the Hour on the Stereographic Projection drawn upon it. This finds the Meridian, Hour, the Sun's Place, Rising, Setting, &c. and many other Propositions of the Globe.

Doubling *the Cape*, or *a Point of Land*, in Navigation, is to come up with it, pass by it, and so to leave it behind the Ship.

Double, or Flank'd Tenaille. See *Tenaille*.

Double *Point*, in Geometry, is one Point consider'd as two infinitely near ones, belonging to Geometrical Curve Lines; or it is an infinitely small Oval, whose bounding Line is become so extremely small, as to be taken for two Points, distant from each other every way by an infinitely small Space; and in the Ellipsis the following Equation will express a double Point, *viz.* $yy = -xx + 2ax - aa$.

Doucine, in Architecture, is an Ornament of the highest Part of the Cornice, or a Moulding cut in figure of a Wave, half Convex, and half Concave.

Dovetailing, in Architecture, is the way of fastening of Boards or Timber together, by letting of one Piece into another indently, with a Dove-Tail Joint, or with a Joint in figure of a Dove's Tail.

Draco, a Constellation in the Northern Hemisphere; consisting of thirty-three Stars.

Dragon's Head and Tail, are the Nodes of the Moon. See *Nodes*.

Dragon-Beams, in Architecture, are two strong Braces or Struts, which stand under a Breast-Summer, and meet in an Angle on the Shoulder of the Key-piece.

Draught Compasses, are Compasses with several moveable Points, to draw fine Draughts in Architecture, &c.

Draught Hooks, are large Hooks fix'd on the Cheeks of a common Carriage, two on each side, one near the Trunion-Hole, and the other at the Train.

Draw-Bridge, is a Bridge made to draw up, or let down, as occasion serves, before the Gate of a Town or Castle: And they are made after several Fashions; but the most common are made with Plyers, twice the Length of the Gate, and a Foot in Diameter. The inner Square is travers'd with a Cross, which serves for a Counter-Poise; and the Chains that hang from the other Extremities of the Plyers, to lift up, or let down the Bridge, are of Brass or Iron.

Drip, in Architecture. See *Larmier*.

Dry Moat. See *Moat*.

Duplicate Proportion, or Ratio, is a Ratio compounded of

two Ratio's; as, the duplicate Ratio of a to b is the Ratio of aa to bb, or of the Square of a to the Square of b.

If three Quantities are in continual Proportion, the first is to the third in the duplicate Ratio of the first to the second; or as the Square of the first to the Square of the second.

Duplication, is the doubling of any thing.

Duplication *of a Cubic*, is to find the Side of a Cube that shall be double in Solidity to a given Cube. Several have attempted to do this geometrically; but it is in vain to pretend to it, for it cannot be done without the Solution of a cubic Equation; and so a conic Section, or some higher Curve, must be used for determining the Problem.

The Solution of this Problem depends upon finding two mean Proportionals between two given Lines. For if the Side of a given Cube be $= a$, and the Side of a double Cube be $= y$, then will $2a^3 = y^3$, or putting $b = 2a$, it will be $aab = y^3$; therefore it will be $aa : yy :: y : b$; or making $z = \frac{yy}{a}$, it will be $a : z :: y : b$. So that these four Quantities will be continual Proportionals: consequently y, the Side of the Cube sought, is the second of two mean Proportionals between a and b.

This Problem of doubling the Cube, formerly was proposed by the Oracle at *Delphos*, to the Inhabitants of that Island, who went to ask what was to be done, to cause the Plague then raging amongst them to cease? The Oracle made answer, that before this could happen they must double the Altar, which was a Cube. See *Valerius Maximus*, Lib. 8. also *Eutocius*'s *Commentary* on Lib. 2. *Archimedes De Sphæra & Cylindro.*

Durable Fortification. See *Fortification*.

Duration, is the Idea we have of the Continuation of the Existence of any thing.

Dialling. See *Dial*.

Dye, or Die, in Architecture, is any square Body, as the Trunk, or notch'd Part of a Pedestal, being that Part included between the Base and the Cornice.

Dyptere, or Diptere, in the antient Architecture, was a kind of Temple, encompassed round with a double Row of Columns; and the Pseudo-Diptere, or false Diptere, was the same, only this was encompassed with a single Row of Columns, instead of a double Row.

E.

EARTH. This Body of Land and Water, whereon we dwell.

Various have been, and now are the Opinions concerning the Shape of the Earth, by such who are ignorant of Geography. That of the common People is, that it is a vastly extended Plane, having a bottomless Foundation. And of this Opinion were *Lactantius* (in *Lib.* 3. c. 24.) and *St. Augustine* (in *Lib.* 16. *De Civitate Dei*,) and several other of the antient Fathers, and less-knowing Philosophers. Concerning the latter of which, see *Aristotle*'s Book *De Cœlo*, Lib. 2. cap. 13. It is not known who was the first that asserted, that the Figure of the Earth was spherical: but this we may be sure, that the Doctrine is very antient, because at the taking of *Babylon* by *Alexander* the Great, Eclipses were set down and computed for many Years before the Nativity of *Christ*, which without the Knowledge of the spherical Figure of the Earth could not have been done: it

being evident that *Thales* the *Grecian* was ſufficiently acquainted with this, becauſe he predicted an Eclipſe of the Sun.

1. That the Figure of the Earth is nearly ſpherical, is ſufficiently confirmed from Eclipſes; eſpecially thoſe of the Moon, which are cauſed by the Shadow of the Earth falling upon the Moon. And ſince this Shadow always appears circular, whether it falls to the Eaſt, Weſt, or South, and its Diameter greater or leſs, according as the Moon is more or leſs diſtant from the Earth; it is evident from Optics, that the Figure of the Earth is, in Appearance at leaſt, ſpherical.—Alſo Eclipſes of the Sun, which are cauſed by the Interpoſition of the Moon between the Sun and thoſe Places where it appears eclipſed: I ſay it could not be determin'd when, and in what Places ſuch Eclipſes ſhould appear, and where not, if the Earth's Figure where unknown. And becauſe the Places where ſuch Eclipſes happen, and where not, are determin'd upon the Suppoſition of the Earth's Surface being ſpherical; it is evident that the ſame is ſpherical.—The ſpherical Figure of the Earth is evinced alſo from the riſing and ſetting of the Sun, Moon, and Stars; which happen ſooner to thoſe who live to the Eaſt, and later to thoſe living Weſtwardly: and that more or leſs ſo, according to the Roundneſs of the Earth.—So alſo going or ſailing to the Northward, the North Pole and northern Stars become more elevated, and the South Pole and ſouthern Stars more depreſs'd; the Elevation Northerly increaſing equally with the Depreſſion Southerly; and either of them proportionably to the Diſtances gone. The ſame thing happens in going to the Southward.——Beſides, the oblique Aſcenſions, Deſcenſions, Emerſions, and Amplitudes of the riſing and ſetting of the Sun and Stars in every Latitude, are agreeable to the Suppoſition of the Earth's being ſpherical: All which could not be ſo, if the Earth were of any other Figure.—Moreover, when one ſtands upon the Shore, and ſees a Ship afar off under ſail, making towards the Land; at firſt we ſee only the Topſails or higheſt Parts, and at the ſame time do manifeſtly behold the Convex Surface of the Sea interpoſed between our Sight and the Hull or lower Parts of the Ship, till ſhe approaches nearer, and this uniformly every way alike, and proportionably to the ſeveral Diſtances; which is an evident Proof of the Roundneſs of the Sea.—Laſtly, the Roundneſs of the Earth moſt manifeſtly appears from the Voyages of ſeveral Perſons of theſe latter Ages, who have ſail'd quite about the ſame. For firſt of all *Ferdinand Magellan, anno* 1519, in 1124 Days; *Francis Drake*, an *Engliſhman, anno* 1577, in 1056 Days; *Thomas Candiſh*, another *Engliſhman, anno* 1586, in 777 Days; *Simon Cordes*, a *Dutchman, anno* 1590; *Oliver Noort*, another *Dutchman, anno* 1598, in 1077 Days; *William-Cornelius Schouteen*, a third *Dutchman, anno* 1615, in 749 Days; *James Heremetes* and *John Huygens, anno* 1623, in 802 Days, conſtantly continuing their Courſe Weſterly, return'd again to *Europe* Eaſterly, obſerving all the way every Phænomenon conſequent from the Roundneſs of the Earth.—Altho' the Surface of the Earth or Sea is ſaid to make but one continued Round, yet this, in reality, is not to be ſo ſtrictly taken, as to have no Inequality in it; but as a Ball, tho' it has ſome Duſt or ſmall Grains of Sand upon it, may ſtill be ſaid to be round; ſo tho' the Land, Hills, and Mountains be ſomewhat raiſed above the ſpherical Surface of the Sea, and ſome Valleys depreſs'd below it, yet

because the greateſt of theſe Inequalities has ſcarcely any ſenſible Ratio to the whole, the whole may well be affirm'd to be round.

It is not many Years ſince the true Figure of the Earth has been diſcovered; for ever before it was taken by Mathematicians and Geographers as perfectly Spherical, excepting the ſmall Inequalities in its Surface of Mountains, Valleys, *&c.* But now it is evident, that the Figure of the Earth is an oblate Spheroid, form'd by the Rotation of an Ellipſis about its leſſer Axis. So that thoſe Diameters are longeſt of all belonging to the Circle between the Middle of the Poles, or the Equator; and thoſe more remote from it, are ſhorter, till you come to the Axis, joining the Poles of the Earth, which is the ſhorteſt of all. What gave the firſt Occaſion to the Knowledge of this, was the Obſervations of ſeveral *Frenchmen* in the *Eaſt-Indies*, about 70 Years ago, (ſee the *Hiſtory of the Royal Academy of Sciences*, by Mr. *Du Hamel*, p. 110, 156, 206. and *L'Hiſtoire de l'Acad. Roy.* 1700, 1701.) who found that Pendulums, the nearer they came to the Equator, perform'd their Vibrations ſlower. From whence it follows, that the Velocity of the Deſcent of Bodies, or Gravity, is leſs in the Countries near the Equator than thoſe near the Poles. And this ſet Sir *Iſaac Newton* and Mr. *Huygens* to work, to find out the Cauſe; which, they ſay, is the Revolution of the Earth about its Axis: for ſince it moves much ſwifter at the Equator than at the Poles, the Diminution of the Weight of Bodies there, muſt be found greater than near the Poles; and ſo thoſe Parts of the Sea, ſituate near the Equator, being by this Cauſe made lighter, are thrown up to a greater height. See this curious Subject fully handled by Mr. *Huygens*, in his Diſcourſe *De Cauſa Gravitatis*, p. 154, and foll. wherein he makes the Ratio of the polar Diameter to that of the Equator, as 577 to 875; and Sir *Iſaac Newton*'s *Princip. Phil. Nat. Mathem.* Lib. 3. where that Ratio in the firſt Edition is as 689 to 692. —See alſo a late Treatiſe, entitled *The Meaſure of the Earth*, by ſeveral *Frenchmen* ſent to the North to meaſure the Earth, by order of the King of *France*, chiefly occaſioned by the Opinion of Mr. *Caſſini*, who would have the Figure of the Earth to be a prolate or egg-form Spheroid, the Axis being longer than a Diameter of the Equator.

2. On Suppoſition that the Sun's Parallax be thirty-two Seconds, the Earth's mean Diſtance from the Sun will be 54,000,000 Miles. But Sir *Iſaac Newton* takes the apparent Diameter of the Earth from the Sun to be twenty-four Seconds; and ſo the Sun's Parallax twelve Seconds; and if ſo, the Sun's Diſtance will be much greater.

3. Since the Earth is of a prolate ſpheroidal Figure, ſwelling out towards the Equator, and flatted or contracted towards the Poles; ſo as the Diameter of it, at the Equator, is longer than the Axis by about thirty-four Miles; upon this Account, there ariſes a ſmall Inequality in the Magnitude of a Degree of Latitude; for they increaſe from the Equator to the Poles by nearly the eight hundredth Part. But this Difference of Increaſe is ſo very ſmall, that in meaſuring Degrees by Inſtruments, it cannot be diſcover'd. Hence it alſo follows, that heavy Bodies do not tend directly to the Earth's Centre, unleſs at the Poles and Equator, but every where perpendicularly to the Surface of the Spheroid.

4. *Diogenes Laertius* ſays, that *Anaximander* a Scholar of *Thales*, who lived about 550 Years before the

the Birth of *Christ*, was the first who gave an account of the Circumference of the Sea and Land.—And his Measure thereof seems to be used by the succeeding Mathematicians, till the time of *Eratosthenes*. *Aristotle*, at the end of Lib. 2. *De Cœlo*, says the Mathematicians, who have attempted to measure the Circuit of the Earth, make it 40000 Stadiums; and this is thought to be that of *Anaximander*.—The next after *Anaximander*, who undertook this Business, was *Eratosthenes*, who lived about 200 Years before *Christ*. He makes the Circuit of the Earth to be 250000 (some say 252000) Stadiums, which *Pliny* makes to be 31500 *Roman* Miles, each of which is reckon'd to be 1000 Passes. He perform'd the thing by taking the Sun's Zenith Distance, and measuring the Distance between two Places under the same Meridian, as *Cleomedes* relates. But this Dimension was taken by many of the ancient Mathematicians to be false; and chiefly *Hipparchus*, who lived 100 Years afterwards, and added 25000 Stadiums to *Eratosthenes*'s Circuit: but for what reason is not known.——The next who measured the Earth was *Possidonius*, who lived in the time of *Cicero* and *Pompey* the Great; he makes the Circumference to be 240000, (according to *Cleomedes*,) but 180000 Stadiums (according to *Strabo*.) He did it by the Altitudes of a Star, and measuring a Distance under the same Meridian.——*Ptolemy*, in his *Geogr.* says, that *Marinus*, a celebrated Geographer, attempted something of this kind; and likewise in Lib. 1. cap. 3. mentions himself as having try'd to do the thing after a different way from any body before him, which was from Places under different Meridians; but does not say how much he found it to be: for he still made use of the Number of 180000 Stadiums, which had been found out by those who went before him.——*Snell* relates from the *Arabian* Geographer *Abelfedea*, who lived about the 1300th Year of *Christ*, that about the 800th Year of *Christ*, *Maimon*, an *Arabian* King, having got together some skilful Mathematicians, commanded them to find out the Circumference of the Earth. And these accordingly made choise of the Fields of *Mesopotamia*, wherein they measured under the same Meridian from North to South, until the Pole became one Degree depress'd. And that Measure they found to be 56 or 56 Miles and a half: and so according to them the Circumference of the Earth is 20160 or 20340 Miles.—It was a long time after before any body else try'd to perform this Business: but at length, *Snell*, a Professor of Mathematics at *Leyden*, in *Holland*, about 120 Years ago began again to set about this Work, who with a great deal of Skill and Labour, by measuring large Distances under the same Parallel, found one Degree to be 28500 Perches, each of which is 12 *Rhindland* Feet, or 19 *Dutch* Miles, and the whole Periphery 6840 Miles; a Mile being, according to him, 1500 Perches or 18000 *Rhindland* Feet. See more in his Treatise, called *Eratosthenes Batavus*.———The next Modern, who undertook this Measurement, was our Countryman *Richard Norwood*, who in the Year 1635, by measuring the Distance from *London* to *York* with a Chain, and taking the Sun's Meridian Altitude, the 11th of *June*, with a Sextant of above five Feet Radius, found a Degree to contain 367200 Feet, or 69 Miles and a half and 14 Poles; and thence the Circumference of a great Circle of the Earth is a little above 25036 Miles, and the Diameter a little more than 7966 Miles. And this Measure is allow'd by every one to be as exact as any whatever.

See

See the Particulars of the whole Affair in his *Seaman's Practice*.

The Measurement of the Earth by *Snell*, tho' very troublesome and ingenious, and much more accurate than any of the Ancients, being thought by some of the *French*, in the Reign of *Lewis* XIV. to be subject to some small Errors, the Affair was renew'd, after *Snell*'s way, by Mr. *Picart* and other Mathematicians, by the *French* King's Command; they using for that Purpose a Quadrant of $3\frac{1}{6}$ *French* Feet Radius, and found a Degree to contain 342360 *French* Feet. See Mr. *Picart*'s Treatise, entitled *La Mesure de la Terre*.—Mr. *Cassini* the younger, in the year 1700, by the *French* King's Command too, went about this Business, with a Quadrant of 10 *French* Feet Radius for taking the Latitude, and another of $3\frac{1}{8}$ Feet for taking the Angles of the Triangle: And found a Degree, from his Calculation, to contain $28\frac{323}{500}$ Toises, or $69\frac{783}{1760}$ *English* Miles. And this Measurement being perform'd with all the Care and Exactness possible, must be look'd upon as very near the Truth; and differs from our *Norwood*'s only 8 Toises. See the *Hist. de l'Acad. Roy. an.* 1702.

5. The Earth's Excentricity is a hundred and sixty-nine of such Parts as the Sun's Distance is a thousand. The periodic Time of the Earth, in her Orbit, is three hundred and sixty-five Days, five Hours, fifty-one Minutes; the Motion about its Axis is performed in twenty-three Hours, fifty-six Minutes, four Seconds; and its Axis makes an Angle with the Plane of the Ecliptic of sixty-six Degrees, thirty-one Minutes.

6. The Earth's Horizontal Parallax to an Eye at the Sun's Surface will be sixteen Minutes; and it is nearer the Sun in *December* than it is in *June*, and consequently its Perihelium is in the Month of *December*, *viz.* about the third or fourth Day.

EARTH-BAGS, in Fortification are the same with Canvass-Bags. Which see.

EAVES-LATH, in Architecture, is a thick feather-edged Board, nail'd round the Eaves of a House for the lowermost Tiles, Slates, &c. to rest upon.

EBBING *and* FLOWING *of the Sea*. See *Tides*.

ECHO, is a Repetition of Sound, caused by Reflection.

ECHINUS, from the *Greek Echinos*, the Shell of a Chesnut, commonly signifies that Part of the Quarter-Round which includes the *Ovum*, or Egg, and sometimes the Quarter-Round itself.

ECLIPSE, is a Deprivation of the Light of the Sun, or some Heavenly Body, by the Interposition of another Heavenly Body between our Sight and it. As an Eclipse of the Sun is the Deprivation of its Light, caused by the Interposition of the Body of the Moon, between our Sight and the Sun. An Eclipse of the Moon is the Deprivation of her Light, caused by the diametrical Interposition of the Earth between the Sun and Moon.

A total Eclipse of the Sun or Moon, is when their whole Bodies are obscured: And a central Eclipse of the Moon, is when it is not only total, but also the Centre of the Moon passes through the Centre of that Circle which is made by a Plane, cutting the Cone of the Earth's Shadow at Right Angles, with the Line joining the Centres of the Sun and Earth. A partial Eclipse, is when Part of the Body of the Sun and Moon are only darken'd.

1. The Moon can never be eclipsed, but when she is in Opposition to the Sun, or at Full; and

likewise in or near the Nodes: And the Sun, but when he is in Conjunction with the Moon, and the Moon is in or near the Nodes.

2. The Limit for Eclipses of the Moon is about 11 deg. 40 min. on each side of the Node: And the Limit for those of the Sun about 16 deg. 40 min. on each side it. Also the utmost Latitude of the Moon, that can permit any Eclipse of the Moon, is about 1 deg. 2 min. And the same utmost Latitude that can permit any Solar Eclipse is about 1 deg. 32 min.

3. If you multiply the Number of Lunar Months, accomplished from that which began the 8th of *January*, N. S. in 1701. to that Month in which any New Moon falls out, and add to the Product 33890, and divide the Sum by 43200; then if the Remainder or the Difference between the Divisor and Remainder be less than 4060, there will be an Eclipse of the Sun that New Moon.

4. Likewise if you multiply the Number of Lunar Months, accomplished from that which began the 8th of *January*, N. S. 1701. to the New Moon preceding any Full Moon, and to the Product add 37326, and then divide the Sum by 43200, if the Remainder or Difference between the Divisor and the Quotient be less than 2800, there will be an Eclipse of the Moon at the said Full.

5. All Eclipses of the Moon are of the same Magnitude all over the Earth, and begin and end at the same Times to all those inhabiting under the same Meridian. But Eclipses of the Sun on various Parts of the Earth, are different: They always begin on the West Side the Sun, and end on the East.

6. Dr. *Halley*, in his Tables not yet published, takes notice of a Cycle, or Period, which Mr. *Whiston* says is two hundred and twenty-three Synodical Months, or eighteen *Julian* Years, ten Days, (when the Cycle, or Period contains five Leap Days,) and eleven Days (when four Leap Days) seven Hours, forty-three Minutes one Fourth; in which time all Correspondent New Moons, Full Moons, and Eclipses return again. This Cycle is, by him, called the *Saros*, and is mentioned by *Pliny* in lib. 2. of his *Natural History*.

7. The principal Alteration of the Time of the Day in all Eclipses, depends upon the Excess of this Period above an even Number of Days, which is seven Hours, and forty-three Minutes one Fourth; so that the Cycle puts every Correspondent Eclipse later than the foregoing almost eight Hours: And so if three of those Cycles are joined together, those odd Hours and Minutes will amount nearly to one Day, and they will nearly bring the middle Point of the Correspondent Eclipses to the same Time in the same Place, which a single Cycle cannot do; and these three Cycles together will be fifty-four Years, and thirty-two or thirty-three Days.

8. There will be elapsed nine hundred Years in the time that the Moon begins to enter the Ecliptic Limit for Eclipses of the Moon on one side, till it goes out of it on the other; in all which time there will be fifty Periods, and Eclipses of the Moon each Period: And there will be elapsed twelve hundred and sixty Years from the time that the Moon begins to enter the Ecliptic Limit for Eclipses of the Sun on one side the Node, till it goes out of it on the other: During which long time there will be seventy Periods, and somewhere Eclipses of the Sun each Period. After which long Spaces of Time there will be no such Eclipses for a much longer time.

9. The

9. The Motion of the Centre of the Shadow of the Moon, in Eclipses of the Sun, is nearly right-lined.

10. The Dimensions of the Penumbra, or entire Eclipse, and the Extent of the total Shadow on the Earth, are continually different, according to the different Elevations of the Sun and Moon above any particular Horizon.

11. The Figure of the entire Penumbra, or general Eclipse, and of the Umbra, or total Darkness, as they appear upon every Country, on account of the different Obliquity of every Horizon, is different, and will make Ovals, or Ellipses of different Species perpetually; and in the vast Penumbra it will be an Oval, being the Intersection of a conical and spherical Surface; but in the smaller Umbra, or total Darkness, which is confin'd to a much narrower Compass, it very nearly approaches to the Intersection of a Conic Surface with a Plane, which is a true Ellipsis.

12. The Species of that Ellipsis depends on the same Altitude above the Horizon at the time of total Darkness, as does the Position of its longer Axis on the Azimuth of the Sun at the same time. This Oval, when the Sun is of a considerable Altitude, is almost an exact one; but when the Sun is near the Horizon, it will be very long, and so less exact, because the spherical Surface of the Earth is at a Distance more remote from a Plane.

13. The perpendicular Breadth of the Shadow is neither that of the longer, nor that of the shorter Axis of the Cone of Shadow; but that of the two longest Perpendiculars, drawn from the Tangents, parallel to the Diameter; along which the Direction of the Motion is.

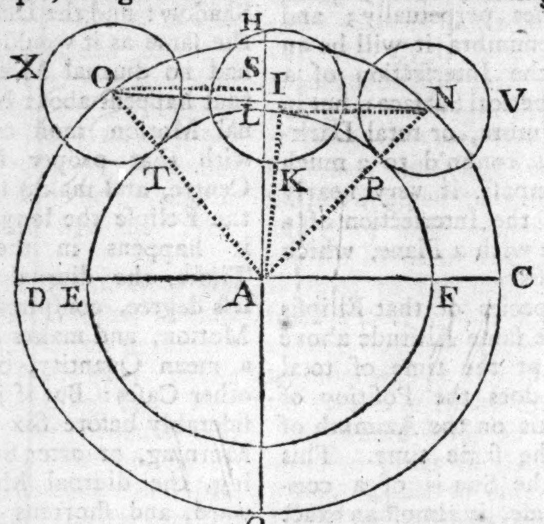
14. The Velocity of the Motion of the Centre of the Shadow is unequal; not only on account of the Difference of the Moon's Motion at the beginning and ending of the entire Eclipse; which indeed is very inconsiderable, but chiefly by reason of the Difference of the Obliquity of the Horizon all the Way of its Passage.

15. The Duration of Solar Eclipses is different, according as their Middle happens about Six in the Morning or Evening, or about Noon, or about any intermediate Time. If that happens about Six o'Clock, Morning or Evening, the diurnal Motion then neither much conspires with, nor opposes the proper Motion of the Centre of the Shadow: and the Duration is almost the same as it would be if the Earth had no diurnal Motion at all. If that happens about Noon, the diurnal Motion, most of all, conspires with that proper Motion of the Centre, and makes the Duration of the Eclipse the longest possible. If it happens in the intermediate Times, the diurnal Motion, in a less degree, conspires with the other Motion, and makes the Duration of a mean Quantity, between that of other Cases: But if it happens considerably before Six o'Clock in the Morning, or after Six in the Evening, the diurnal Motion is backward, and shortens that Duration proportionably.

16. The Computation or Calculation of Eclipses of the Sun, is at best but a troublesome Business; that of the Moon being easier than that of the Sun. The Moon's consists in having the following Data: 1. Her true Distance from the Node, at the mean Conjunction. 2. The true Time of the Opposition, together with the true Place of the Sun and Moon, reduced to the Ecliptic. 3. The Moon's true Latitude at the time of the true Conjunction, and the Distance of each

each of the Luminaries from the Earth; as also their horizontal Parallaxes and apparent Semi-diameters. 4. The true horary Motions of the Moon and of the Sun; and the apparent Semi-diameter of the Earth's Shadow. From these being given, the Duration, Beginning, Middle, End, and Quantity of the Eclipse, may be obtain'd from Addition, Subtraction, the Rule of Proportion, and Trigonometry.

A Type of an Eclipse of the Moon may be described *in plano*, when the Semi diameter of the Moon and Earth's Shadow, as also the Latitude at the Beginning and End of the Eclipse, are given: For let CD be the Ecliptic, and A the Centre of the Shadow; thro' which draw LQ perpendicular to DC. Let D, H, C, Q, be West, North, East, and South. From A with the Distance equal to the Sum AN of the Semi-diameters of the Shadow AP, and that of the Moon PN describe a Circle DOCQ, and with AP the Semi-diameter of the Shadow describe another concentric Circle ELF, which will exhibit the Section of the Earth's Shadow during the Moon's Passage. Make AL equal to the Moon's Latitude at the Beginning of the Eclipse, and at L raise the Perpendicular LN meeting the greater



Periphery towards the West in the Point N; then will the Centre of the Moon be at N at the Beginning of the Eclipse. In like manner make AS equal to the Moon's Latitude at the End of the Eclipse, and at S raise the Perpendicular OS, which being parallel to DC, is at the same Distance from it; then will the Centre of the Moon be in O, at the End of the Eclipse. Join the Points O and N by a right Line; then will ON be an Arch of the Orbit, which the Moon's Centre moves thro' during her Obscuration. From O and N, with the Distance of the Moon's Semi-diameter, describe the Circles PV, TX, which will express the Moon at the Beginning and End of the Eclipse. Lastly, from A draw AI perpendicular to ON, then will the Centre of the Moon in the middle of the Obscuration be at I; and so if a Circle HK be described from I, with the Distance of the Moon's Semi-diameter; it will represent the Moon in her greatest Obscuration, and will define the Quantity of the Eclipse.

The Calculation of an Eclipse of the Sun depends upon the following Data: 1. The mean Conjunction, and from thence the true Conjunction, together with the Place of the Luminaries at the apparent Time of the true Conjunction. 2. The apparent Time of the visible new Moon at the apparent Time of the true Conjunction. 3. The apparent Latitude at the apparent Time of the visible Conjunction. When these are once had, the other *Quæsita* may be obtained by Trigonometry, and other Helps. But to get the Data, the greatest Part of the Trouble consists in the Parallaxes of Longitude and Latitude, which if there were no such thing, it would make the Calculation of solar Eclipses the same as that of lunar ones.

17. M. *De la Hire*, has given the Description of an Instrument to find out Eclipses by, as may be seen in *Bion*'s Book of Mathematical Instruments: You have also a geometrical way of projecting an Eclipse of the Sun, by a Pair of Compasses and a Sector, which may be seen in Vol. II. of Sir *Jonas Moor*'s *Mathematics:* In Dr. *Keil*'s *Astronomical Lectures:* At the End of my Translation of *Bion*'s Book of Mathematical Instruments; and in a little Tract of the Use of the *Sector*, printed for Mr. *Wright*, a Mathematical Instrument-maker.

18. *Plutarch* relates in his Life of *Nicias*, that when Soldiers were commanded to embark upon an Expedition, there happen'd that Night an Eclipse of the Moon, which very much surprized their General, and all the Soldiers, and by reason of their Ignorance of the Cause thereof, it possessed them with great Apprehensions of ill Luck: For, says he, many knew the Cause of Eclipses of the Sun, but they had not the least suspicion what should make the Moon, when shining with a full Face, to instantly lose her Light and Colour; and interpreted this to be no other than a Token sent by God of some impending Calamity that would happen to them.— In the same place *Plutarch* takes notice, that *Anaxagoras*, who flourish'd but a little before *Nicias*, was the first who had the Boldness to communicate in Writing, the Cause of the lunar Light and Shadow. But his Opinion was yet conceal'd from the Public, who would not easily admit or approve of any Writings concerning the Causes of natural Appearances; but looked upon all such who employed their Times this way, as Men busying themselves in vain Pursuits, and guilty of Impiety to bound and limit the Deity with certain Laws; and for this was *Protagoras* banish'd from *Athens*, and *Anaxagoras*, when carried to Prison, was released by *Pericles* with much ado.

19. *Thales* was the first who predicted an Eclipse of the Sun; and *Ptolemy* in *Lib.* 6. of his *Almagest*, has shewn how to find an Eclipse of the Sun by means of Parallaxes, which *Regiomontanus* in his *Epitome Almagesti*, Lib.6. has fully explain'd. See also, concerning Eclipses —— *Hevelius*'s *Machin. Cœlest.* tom. 1. c. 18. f. 372. *et seq.*— *De la Hire*'s *Tabulæ Astronomicæ.*— *Wing*'s *Astronomia Britannica.*— *Wideburg*'s *Tractat. de Eclips. totali Solis et Terræ, anno* 1715. d. 3. *Maij.*— *Gregory*'s *Element. Astronom. Phys. & Geom.*—*Wolfius*'s *Elem. Astron.* §.841. & §. 913.— *Leadbetter*'s *Doctrine of Eclipses.*—See also the Transactions of the Learned, published at *Petersburgh*, wherein is a Method of computing Eclipses by Series's. One of the principal Uses of Eclipses is to find the Longitude of Places. See under the Word *Longitude*.

Ecliptic, is a great Circle of the Sphere, supposed to be drawn thro'

thro' the middle of the Zodiac, and making an Angle with the Equinoctial (in the Points of *Aries* and *Libra*) of 23 deg. 30 min. which is the Sun's greatest Declination. But in the new Astronomy, it is that Path or Way among the fixed Stars that the Earth appears to describe to an Eye placed in the Sun.

This is, by some, called *Via Solis*, or the *Way of the Sun*, because the Sun, in his annual Motion, never deviates from this Line, as all other Planets do, more or less; from whence the Zodiac hath its Breadth.

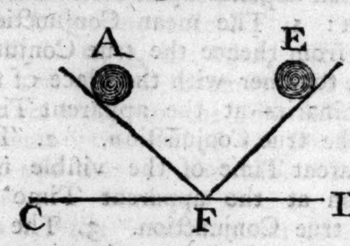
Effection, is a Word used by Geometers, in the same sense with the Geometrical Construction of Propositions, and often of Problems and Practices; which, when they are deducible from, or founded upon some general Proposition, are called the Geometrical Effections thereunto belonging.

Effluviums, are the very small Particles, or Corpuscles that are continually emitted from Bodies.

Elasticity, is the same as Springiness: And an elastic Body is that which gives way for a time (or lessens its Figure) to another Body, striking or pressing it, but presently recovers its former Figure by its own natural Power: And a Body perfectly elastic, is one that recovers its Figure with the same Force it lost it by.

All Bodies in Nature, that we know of, are in some degree or other, elastic, but none of them are perfectly elastic; and from this Elasticity of Bodies proceeds that noted Law of Nature, *viz. That Action and Re-action are always equal and contrary*: For if there was no Elasticity, this Law would not hold good.

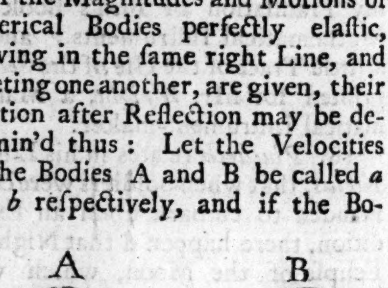
If the elastic Ball A strikes against the firm Bottom CD obliquely in the Direction AF, the Angle EFD, whose Side FE it rebounds back again in, will be equal to the Angle AFC.



If a String be strained like those of a musical Instrument, it shall become elastic; for the smallest Force shall be sufficient to bend it, tho' it be strained never so hard; and when that Force ceases, the Force that strains it, shall bring it back to its first Situation, and the String being once mov'd, shall oscillate like a Pendulum, and perform them all, both great and small, in the same time.

Most elastic Bodies, when struck, give a musical Sound; and the Reason why some do not, seems to be either because the Spring is too weak, and the Motion too slow, or because the Elasticity is too strong, and the vibrating Parts so short, and the Sound so acute, and so soon over, that it cannot be perceived by the Ear.

If the Magnitudes and Motions of spherical Bodies perfectly elastic, moving in the same right Line, and meeting one another, are given, their Motion after Reflection may be determin'd thus: Let the Velocities of the Bodies A and B be called *a* and *b* respectively, and if the Bodies tend the same way, and A moving swifter than B, follows it, then the Velocity of the Body A after



after the Reflection will be $\frac{aA-aB+2bB}{A+B}$ and that of the Body $B=\frac{2aA-bA+bB}{A+B}$. But if the Bodies meet, then changing the Sign of b, the Velocites after Reflection will be $\frac{aA-aB-2bB}{A+B}$, and $\frac{2aA+bA-bB}{A+B}$; either of which, if they happen to come out negative, it follows that the Motion after Reflection tends the contrary way to which A tended before the Reflection. And this is also to be understood of the Motion of the Body A in the former Case.

The Cause of Elasticity, in most Bodies, seems to be the repulsive Force of their Particles; for when the elastic Body is compressed, its Pores are thereby contracted, and made smaller; so that many Particles, which were at some distance before, are now brought nearer together, within the Sphere of each other's Repulsion; which Repulsion grows stronger as the Compression increases, and the Particles are forced closer to each other: Wherefore, if the Pores of a Body are very large, it may admit of Compression without much Elasticity. And hence also, we see the Reason why the Elasticity of Metals is increased by hammering.

Sir *Isaac Newton*, in *Prop.* 23. *lib.* 2. *Princip.* demonstrates, That Particles which mutually avoid, or fly from one another by such Forces as are reciprocally proportional to the Distances of their Centres, will compose an elastic Fluid, whose Density shall be proportional to its Compression.

Electricity, is that Property of some Bodies, as Amber, Jet, Sealing-wax, Glass, &c. whereby they attract, or repel all kinds of very light Bodies at a sensible Distance, when the attracting Body is heated by being rubb'd. And this Electrical Attraction is nothing else but the Attraction of Cohesion, excited by a strong Attrition to act with less Force in a larger Sphere.

It is evident from several Experiments, that in electrical Attraction, the Particles of Light and Æther are forcibly repelled or driven away from the electrical Body, and that this Force reaches to a considerable Distance, but is strongest near the electrical Body.

If a Glass Tube fifteen or eighteen Inches long, and one Inch in Diameter, be rubbed with a Cloth, it has a very sensible Electricity; for if light Bodies, such as Pieces of Leaf-Gold and Soot be laid upon a Plane, and the Tube be brought near them, they will be put in motion, attracted, repelled, and driven several ways by the Tube. The Tube acts at different Distances, according to the different State of the Air; sometimes at the Distance of one Foot; but when the Air is full of Vapours, the Effect is diminished; and the Tube must be rubbed all one way from the End that your Hand does not hold it with.

Elements, by Geometricians and Natural Philosophers, are usually taken for the same as Principles; and when they say the elementary Principles of natural or mix'd Bodies, they mean the simple Particles out of which the mix'd Body is composed, and into which it is ultimately resolvable. The Word is also used for the first Principles or Rudiments of any Science; as the *Elements of Euclid*.

Elevation *of a Mortar-piece*, signifies the Angle which the Chace of the Piece, or the Axis of the Cavity of the same makes with the Horizon.

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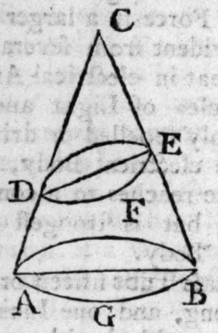
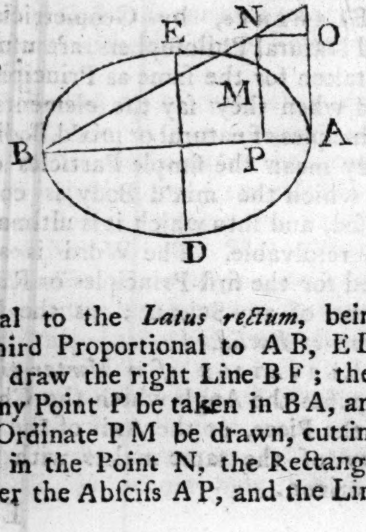
Elevation *of the Pole*, is the Number of Degrees that the Pole is raised above the Horizon of any Latitude.

Ellipsis, in Geometry, is a Curve Line as D E F returning into



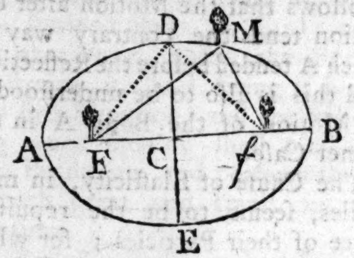
itself, and is the common Section of the Surface of a Cone A C B, generated by a Plane, so cutting it as when continued, it falls above the Base A G B of the Cone.

The Reason of this Name which *Apollonius* first gave to this Curve, is this: Let B A, E D, be any two conjugate Diameters of an Ellipsis (they are the Axes in this Figure) and at the End A of the Diameter B A, raise the Perpendicular A F



equal to the *Latus rectum*, being a third Proportional to A B, E D, and draw the right Line B F; then if any Point P be taken in B A, and an Ordinate P M be drawn, cutting B F in the Point N, the Rectangle under the Abscis A P, and the Line P N will be equal to the Square of the Ordinate P M; and since (drawing N O parallel to A B) this Rectangle is less than that under A P, and the *Latus rectum* A F, by the Rectangle under A P and O F, or N O and O F, being similar to that under A B and A F; the said Deficiency made him call the Curve by the Name of an *Ellipsis*.

The easiest way of describing this Curve by a continued Motion when the transverse and conjugate Axes AB, ED, are given, is thus: First

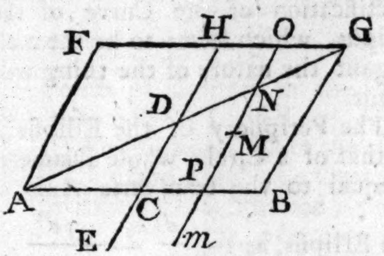


take the Points F, *f*, in the transverse Axis, such that the Distances C F, C *f*, from the Centre C be each equal to $\sqrt{AC-CD}$, or such that F D, *f* D be each equal to A C; and having affix'd two Pins in the Points F, *f*, (which are call'd the Foci of the Ellipsis) take a Thread equal in Length to the transverse Axis A B, and put about them, and fasten the two Ends of the Thread together at M; then if this Thread be drawn tight by means of a Pin M, and the said Pin be moved round till it returns to the Place from whence it first moved, and the Thread at the same time being always kept tight, so as to form a right-lin'd Triangle F M *f*; the said Pin M will describe an Ellipsis, whose Axes are A B, D E. And by this means may Points, thro' which the Curve is to pass, be found; for if with any Distance less than the Axis A B you describe an Arch of a Circle about the Centre F, and with another Distance equal to what

the

the ſaid Diſtance wants of being equal to A B, you deſcribe another Arch about *f*, interſecting the former one; the ſaid Point of Interſection will be one Point of the Ellipſis.

If it be requir'd to find Points thro' which an Ellipſis of given conjugate Diameters A B, E D, is to paſs, it may be done thus: Continue out C D to H, ſo that D H be = D C, thro' H draw F G parallel to A B, and A F, B G parallel



to C H, and draw the Diagonal A G. Take any Point P in A B, and draw P O parallel to A F, cutting A G in N; then if P M be a mean Proportional between P N, P O, the Point M will be a Point of the Ellipſis. And thus may any Number of Points be found for one half the Ellipſis; and to find them for the other half, it is but continuing out O P below A B, and making P*m* equal to P M, then will *m* be a Point in the other half of the Ellipſis.

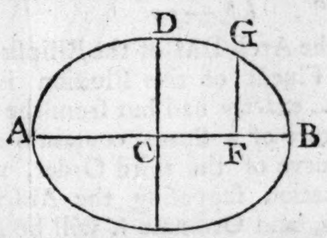
There are many other ways of deſcribing an Ellipſis by a continued Motion, and by means of Points, —As by moving the Angle of a Square along a right Line, and at the ſame time letting the End of one ſide of the Square paſs along a given Point without that Line; for then the Extremity of the other ſide of the Square will deſcribe an Ellipſis.— By faſtening the Angles of two Squares in two Points upon a Plane, and cauſing the Interſection of two Sides of the Squares to move along a right Line, drawn in a certain Poſition in that Plane; for then the Interſection of the other two of theſe Squares will deſcribe an Ellipſis; or inſtead of two Squares you may have only one, and a Ruler, and an Ellipſis will ſtill be deſcribed.

An excellent general way of finding Points, thro' which this Curve and the other two conic Sections paſs, may be ſeen under the Word *Geometrical Curve*. See various ways of deſcribing an Ellipſis in *Gregory St. Vincent*'s *Quadratura Circuli*.

1. The Area of the Elliptic Space is a mean Proportional between the two Circles, having the tranſverſe and conjugate Axes for their Diameters.

2. The Periphery of the Ellipſis may be obtained by the following Series.

For if C B, half of one of the Axes of an Ellipſis be $= r$, and C D, the half of the other, $= c$, and there be let fall a Perpendicular



G F to A B, which call a; then the Length of the Curve of the Ellipſis G B will be $= a + \frac{r^2 a^3}{6c^4} + \frac{4r^2c^2a^5 - ra^5}{40c^8} + \frac{8c^4r^2a^7 + r^6a^7 - 4c^2r^5a^7}{112c^{12}}$ &c.

And if the Species of the Ellipſis be determined, this Series will be more ſimple; and if $c = 2r$, then will $BG = a + \frac{a^3}{96r^2} + \frac{3a^5}{2048r^4} +$

$$+\frac{113\,a^7}{458752\,r^6}+\frac{3419\,a^9}{75497472\,r^8}\ \&c.$$

And if the ſaid Curve was an Hyperbola, the ſaid Series would ſerve for it, by making the even Parts of all the Terms affirmative, and making every third, fifth, and ſeventh Term negative.

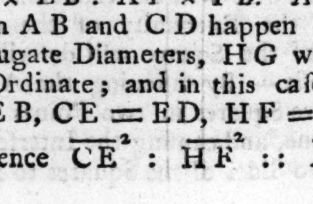
3. In the Ellipſis, (ſee Fig. of n. 2.) if a Semi-diameter C B be called a, the Semi-conjugate C D, b, the Abſciſs C F, x, and the correſpondent Ordinate F G, y; then will the Equation $yy = \frac{m}{n} \times \overline{aa - xx}$, be the moſt ſimple poſſible, expreſſing the Curve of the Ellipſis, m and n being invariable Quantities.

The Rectification of the Curve of the Ellipſis cannot be had from the Quadrature of any Space belonging to the Conic Sections; for if DC, CB be the Semi-Axes, and $dd = aa - bb$, *viz.* equal to the focal Diſtance, and $ccdd$ be $= b^4$, then will $\dot{y}\,\frac{d}{b}\sqrt{\frac{cc+yy}{bb-yy}}$, be the Fluxion of the Arch DM of the Ellipſis, and the Fluent of this Fluxion is not to be exactly had but from the Quadrature of a Space contain'd under a Curve of the third Order, whoſe Equation ſuppoſing the Abſciſs to be u, and Ordinate y, will be $uuyy + ddyy = bbuu - ddcc$.

But if z be a correſpondent Arch of a Circle deſcribed about the Centre A with the Radius A C, the Fluxion of the Arch of the Ellipſis will be $\dot{z}\,\frac{1}{ab}\sqrt{aabb + ddyy}$. So that the Rectification of the Curve of the Ellipſis alſo may be had from the Quadrature of the outward Curve Surface of a Cylinder (whoſe Baſe is the Circle deſcribed upon the tranſverſe Axis of the Ellipſis) remaining after the Cylinder is cut thro' by the Curve of an Hyperbola (whoſe ſemi-tranſverſe Axis is a, and Semi-conjugate $\frac{ab}{d}$) in ſuch manner that the Semi-tranſverſe moves in a Plane paſſing thro' the Axis of the Cylinder, the Plane of the Hyperbolic Space moving always parallel to itſelf, and the Centre of the Hyperbola running along a Diameter of the Baſe of the Cylinder. In Mr. *Simpſon*'s Book of Fluxions, you have the following Series for the Rectification of the Curve of the Ellipſis, which ſeems to be the moſt elegant the nature of the thing will admit.

The Periphery of the Ellipſis is to that of a Circle, whoſe Diameter is equal to the tranſverſe Axis of the Ellipſis, as $1 - \frac{d}{2.2} - \frac{3d^2}{2.2.4.4} - \frac{3.3.5\,d^3}{2.2.4.4.6.6.} - \frac{2.3.5.5.7\,d^4}{2.2.4.4.6.6.8.8.}\ \&c.$ is to 1, where d is equal to the Difference of the Squares of the Axes apply'd to the Square of the tranſverſe Axis.

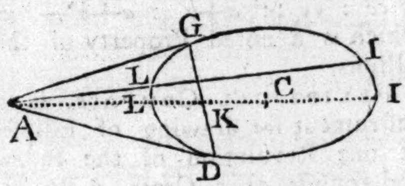
4. If any two parallel right Lines, C D, H G, be drawn, terminating in an Ellipſis in the Points C, H, D, G, and a third Line A B, terminating in the ſame in the Points A, B; then will C E × E D : H F × F G ::



A E × E B : A F × F B. And ſo, when A B and C D happen to be conjugate Diameters, H G will be an Ordinate; and in this caſe A E = E B, C E = E D, H F = F G. Whence $\overline{CE}^2 : \overline{HF}^2 :: \overline{AE}^2 :$ AF

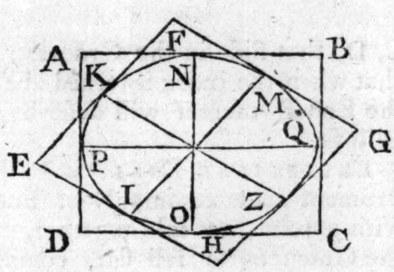
A F × F B, which is a very noted Property of the Ellipsis.

5. If any two right Lines, touching an Ellipsis in the Points G, D, meet in the Point A, and from A be drawn the right Line A L I, meeting the Curve in the Points L, I, and the Line G D joining



the Points of Contact in the Point K; then will A L : A I : : K L : K I. And so since, when the right Line L I passes thro' the Centre C of the Ellipsis, it is bissected; therefore C K, C I, C A, are continual Proportionals. See more under *Hyperbola*.

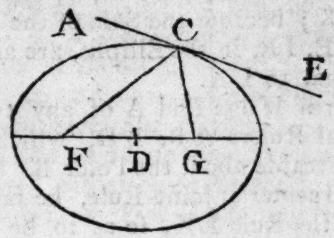
6. In every Ellipsis a Parallelogram, as E F G H, that circumscribes it, so that its Sides be parallel to the two conjugate Diameters K Z, M I, is equal to the Rectangle



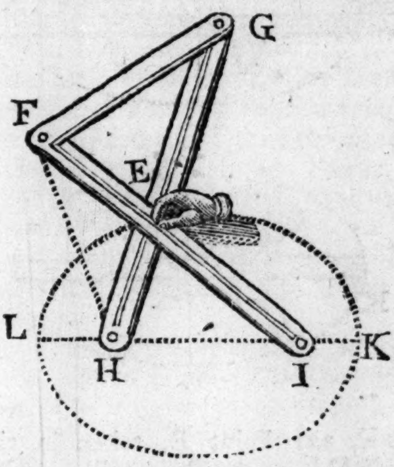
A B C D, whose Sides are equal to the two Axes N O, P Q. See more under *Hyperbola*.

7. In every Ellipsis the Sum of the Squares of any two conjugate Diameters is equal to the Sum of the Squares of the two Axes.

8. In every Ellipsis the Angles A C F, G C E, made by the Tangent A E, and the Lines F C, C G, drawn from the Foci, are equal to one another.



9. If the Line L K be the transverse Axis of an Ellipsis, and Points H, I, the two Foci, and the Rulers, H G, I F, be in Length equal to L K, and the Rule F G to H I; and if the Ends of the Rules, H G,



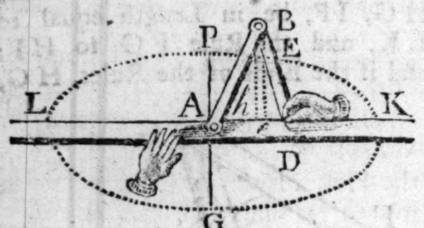
I F, be moveable about the Foci, H, I, and the Rule F G be fasten'd to them, so as to be moveable about the Points F, G; then will the Intersection of the Rules H G, I F, describe an Ellipsis.

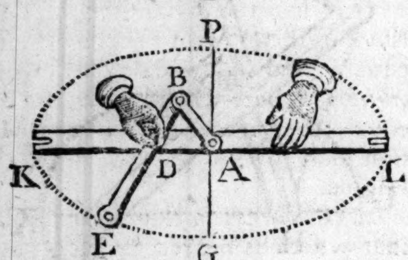
That this Curve will be an Ellipsis, will appear thus. Join F H; for because the Triangles F G H, F I H, have two Sides, F G, G H, each equal to the two Sides HI, IF, and the Base F H common, the Angles FHG, HFI, will be equal; and so the Sides, F E, E H, are equal: Whence F I = H E + E I; but FI is equal to LK; whence HE

+

$+$ E I $=$ to the Axis; and consequently the Point E is in the Ellipsis, whose Foci are H, I, and Axis L K; because the Sum of the Lines H E, I E, in the Ellipsis, are always equal to L K.

10. If one End A of any two equal Rulers A B, B D, which are moveable about the Point B, like a Carpenter's Joint-Rule, be fasten'd to the Rule L K, so as to be made moveable about the Point A, and the End D of the Rule DB be drawn along the Side of the Rule

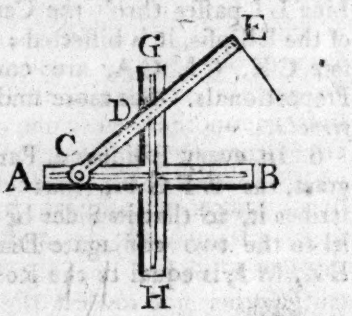




L K, any Point E, taken in the Side D B of the Rule, will describe an Ellipsis, whose Centre is A, conjugate Axis $=$ 2 DE, and transverse $=$ 2 A B $+$ 2 B E.

The following Demonstration of this Property being new, at least to me, is the reason I put it down. Let us call BD, a; BE, b; DE, c; Ae, x; eE, y; $h\,e$, u; hD, q; and eD, z. Then $xx+cc-yy=2qq+2uu$ (by 9. 2. *Euclid*). But since $aa : qq :: bb : uu$. And (by compounding) $aa : qq :: 2aa+2bb : 2qq+2uu$. or $cc : cc-yy :: 2aa+2bb : 2yy+2uu$; because $aa : yy :: cc : zz$. Therefore $cc : cc-yy :: 2aa+2bbxx+cc-yy$. since $xx+cc-yy=2qq+2uu$. and (*dividendo*) $cc : 2aa+2bb :: yy : 2aa+2bb-cc+yy-xx$. And again (*dividendo*) $cc : yy :: 2aa+2bb-cc : 2aa+2bb-cc-xx$. But since $2aa+2bb-cc$ is $= 4bb+4bc+cc$. for $a=b+c$. Therefore $cc : yy :: 4bb+4bc+cc : 4bb+4bc+cc-xx$. But $4bb+4bc+cc=\overline{a+b}^2$. Consequently $cc : yy :: \overline{a+b}^2 : \overline{a+b}^2 - xx$. which is a noted Property of the Ellipsis.

Elliptical Compass, is an Instrument for drawing of Ellipses at one Revolution of the Index, and consists of a Cross A B G H, with Grooves in it; and an Index C E, which is fasten'd to the Cross by means of Dove-tails at the Places



C, D, that slide in the Grooves; so that when the Index is turned about, the End E thereof will describe an Ellipsis.

Elliptical Dial, is an Instrument made commonly of Brass, with a Joint, to fold together, and the Gnomons to fall flat, commodiously contrived to take a little room in the Pocket. By it may be found the true Meridian, Hour of the Day, Rising and Setting of the Sun, with several other Propositions of the Globe.

Elongation *of a Planet*, or *Angle of Elongation*, in Astronomy, is the Difference between the Sun's true Place, and the Geocentric Place of that Planet.

The

The utmost Elongation of *Venus* can be but forty-five Degrees, and that of *Mercury* but thirty Degrees, which is the reason this Planet is so rarely seen.

Embolus, is the Sucker of a Pump, or Syringe; which when the Pipe of the Syringe is close stopped, cannot be drawn up but with the greatest Difficulty; and when forced up by main Strength, will, on being let go, return again with great Violence.

Embrasure, in Architecture, is the Enlargement made in the Walls, to give more Light and greater Convenience to the Windows and Doors of a Building.

Embrasures, in Fortification, are the Holes in a Parapet, through which the Cannons are pointed to fire into the Moat or Field. They are generally twelve Foot Distance from one another, every one of them being from six to seven Foot wide without, and about three within. Their Height above the Platform is three Foot on that side toward the Town, and a Foot and a half on the other side toward the Field; that so the Muzzle may be sunk on occasion, and the Piece brought to shoot low.

Emersion, in Astronomy, is the Time when any Planet, that is eclipsed, begins to emerge, or get out of the Shadow of the eclipsing Body. When any Body also, lighter in Specie than Water, being thrust violently down into it, rises again, 'tis said to emerge out of the Water.

Eminential Equation, a Word of no great use, is an artificial Equation, containing another Equation eminently, and is used in the Investigation of the Area's of curv'd Spaces.

Empattement, by some is the same with *Talus* in Fortification. Which see.

Enceinte, a *French* Term, in Fortification, signifying the whole Inclosure, Circumference, or Compass of a fortified Place, consisting either of Bastions, or not.

Endecagon, a plain Figure, of eleven Sides and Angles.

Enfilade, in Fortification, signifies a Situation of Ground, which discovers a Post according to the whole Length of a right Line, so that it can be scoured with the Cannon, and render'd almost defenceless. Whence, to

Enfile the Curtain or Rampart, is to sweep the whole Length of it with the Cannon.

Engine, in general, is any mechanic Instrument, composed of Wheels, Screws, Pullies, &c. by the Help of which a Body is either moved or hinder'd from moving.

1. When the Quantities of Motion, in the Weight and Power, are equal, the Engine shall stand *in Equilibrio*; but when they are unequal, the greater Quantity of Motion shall overcome and work the Engine.

2. Of Forces in themselves equal, that which is nearest to that Point of the Engine, about which the Weight and Power move, or upon which they sustain each other, is relatively the weakest upon the Engine; for as the Engine works, the nearest Force moves the slowest, and therefore has the least Quantity of Motion.

3. The Effect of any Force upon the Engine will not be changed; if, without changing the Line of Direction, it is only placed in some other Point of the same Line. The Nature of any Engine is explained, when it is known in what Circumstances the Weight and Power will be *in Equilibrio* upon that Engine.

4. In all Engines whatsoever, the Weight and Power will be *in Equilibrio*, when their Quantities are in

the reciprocal Proportion of the Velocities, which the working of the Engine will give them.

5. If an Engine be composed of several simple Engines, the Power is to the Resistance when it counterballances it, in a Ratio compounded of all the Ratio's, which the Powers in each simple Engine would have to the Resistance, if they were separately applied.

Engonasis Hercules, the Name given by Astronomers to one of the Northern Constellations, containing about forty-eight Stars.

Engyscope, the same with a *Microscope*. Which see.

Enharmonical, or Enharmonic, in Music, is usually applied to the last of the three Kinds, abounding in *Dieses*, which are the least sensible Divisions of a Tone. See *Diesis*.

Enneadecaterides, the same with the *Golden Number*. Which see; or the Cycle of the Moon.

Enneagon, is a Polygon of nine equal Sides.

Entablature, or Entablement, in Architecture, signifies the Architrave, the Freeze, and the Cornice together, and is different in the different Orders.

Envelope, in Fortification, is a Mount of the Earth, sometimes raised in the Ditch of a Place, and sometimes beyond it, being either in form of a simple Parapet, or of a small Rampart, border'd with a Parapet. These Envelopes are made when one would only cover the weak Places with single Lines, without any Design of advancing toward the Field, which cannot be done but by Works that require a great deal of Breadth, such as *Horn-Works*, *Half-Moons*, &c.

Epact, is a Number expressing the Excess of a Solar Year above a Lunar one, and is only of use in finding the Age of the Moon.

If the Golden Number be given, and it be divided by 3, and the Remainder be multiplied by 10, and added to the Golden Number, and from the Sum, 30 be taken away, the Remainder will be the Epact.

Epaule, in Fortification, is the Shoulder of the Bastion, or the Angle of the Face and Flank; whence that Angle is often called the *Angle of the Epaule*.

Epaulement, in Fortification, is a Side-work, made either of Earth thrown up, of Bags of Earth, Gabions, or of Fascines and Earth; of which latter they make the Epaulements of the Places of Arms for the Cavalry behind the Trenches.

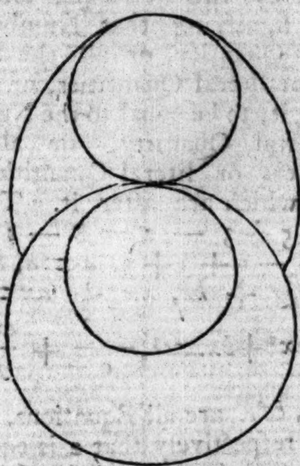
Epaulement, is used for a Demi-Bastion, and sometimes it signifies a square Orillon, which is a Mass of Earth almost square, faced and lined with a Wall, and designed to cover the Cannon of a Casemate.

Epicycle, is a small Circle, whose Centre is in the Circumference of a greater, or a small Orb, which being fixed in the Deferent of a Planet, is carried along with its Motion, and yet with its peculiar Motion, carries the Body of the Planet fasten'd to it round about its proper Centre; which ancient Astronomers attribute to all the Planets, for solving their Appearances, except the Sun.

Epicycloid, is a Curve generated by a Point taken in the Periphery of a Circle that rolls or revolves upon the Periphery of another Circle, either within or without it.

The Length of any Part of the Curve, that any given Point in the revolving Circle has describ'd from the Time it touched the Circle it revolv'd upon, shall be to double the vers'd Sine of half the Arch, which all that time touched the Circle at rest, as the Sum of the Diameters of the Circles, to the

Semi-Diameter of the resting Circle, if the revolving Circle moves



upon the Convex-side of the resting Circle: But if upon the Concave-side, as the Difference of the Diameters, to the Semi-Diameter.

If a Parabola moves upon another equal to it, the Focus of it will describe a right Line perpendicular to the Axis of the Parabola at rest, and at a Distance from it equal to the Distance of the Vertex from the Focus, and the Vertex of the Parabola will describe the Cissoid of *Diocles*, and any other Point thereof will describe some one of the defective Hyperbola's of Sir *Isaac Newton*, having a double Point in the like Point of the Parabola at rest.

If in like manner an Ellipsis revolves upon another, equal and similar to it, the Focus will describe a Circle, whose Centre is in the other Focus, and the Radius shall be equal to the Axis of the Ellipsis; and any other Point of the Plane of the Ellipsis shall describe a Line of the fourth Order. The same may be said also of an Hyperbola, revolving upon another, equal and similar to it; for one of the Foci will describe a Circle, having its Centre in the other Focus, and the Radius shall be the principal Axis of the Hyperbola, and any other Point of the Hyperbola shall describe a Line of the fourth Order.

See concerning these Lines in Lib. 1. of Sir *Isaac Newton*'s *Princip. Mathem.* Also Mr. *De la Hire*, in his *Memoires de Mathematique & de Physique*, wherein he shews the Nature of this Line, and its Use in Mechanics. See also Mr. *Mac-Laurin*'s *Geometria Organica.*

EPISTYLE, in Architecture, is a Mass of Stone, or Piece of Timber, laid upon the Capital of a Pillar.

EPOCHA, or EPOCHE, in Chronology, signifies some remarkable Occurrence, from whence some Nations date and measure their Computation of Time.

The *Julian Epocha* takes its Name from *Julius Cæsar*'s Reformation of the *Roman* Calendar, which was done forty-five Years before Christ, in the seven hundred and eighth Year from the Building of *Rome*, and in the seven hundred and thirty-first Olympiad.

The *Ethiopic*, *Abyssinian*, or as some call it, the *Diocletian Epocha*, or others, the *Æra of the Martyrs*, because it bore a Date with a very severe Persecution; this *Epocha* began *August* 29, *A. D.* 284. and in the third Year of the Emperor *Diocletian*. 'Tis used by the *Egyptians* and *Abyssyns*.

The *Turkish*, or *Arabic Epocha*, which they call the *Hegira*, bears a Date from *Mahomet*'s Flight from *Mecca*, *A. D.* 622, *July* 16.

The *Persic*, or *Jesdegerdic Epocha*, takes its Date either from the Coronation of the last *Persian* King *Jesdegerdic*, or *Jesdagerdis*, as some say, or from his being conquer'd rather by *Ottoman* the *Saracen*, which was *June* 16. *A. D.* 632.

EQUABLE MOTIONS, are such as always continue the same Degree

of Velocity, and are neither accelerated nor retarded; but if there be an Acceleration or Retardation of the Velocity of two or more Bodies, and it be exactly and uniformly the ſame in them both, or all, they ſay, ſuch Bodies are

EQUABLY *accelerated* or *retarded*.

EQUALITY, is the exact Agreement of two Things, in reſpect of Quantity.

A plainer Definition of Equality, is this; thoſe Things are equal to one another, which poſſeſs the ſame Place, or may be conceived to poſſeſs the ſame Place by the Flexion and Tranſpoſition of their Parts. See a learned Diſcourſe about this, by Dr. *Barrow*, in his 11th and 12th Mathematical Lectures.

EQUATION, or *the total Proſtaphæreſis*, in the *Ptolemaic* Theory of the Planets, is the Difference between the Planets mean and true Motion, and the Angle made by the Lines of the true and mean Motion of the Centre. But the

EQUATION, *or* PHYSICAL PROSTAPHÆRESIS, is the Difference between the Motions of the Centre of the Epicycle in the Equant, and in the Eccentric. And the

EQUATION, *or* OPTICAL PROSTAPHÆRESIS, is the Angle made by two Lines drawn from the Centre of the Epicycle to the Centre of the World, and of the Eccentric.

EQUATION *of the Orbit*, is the ſame with the *Total Proſtaphæreſis*, or *Equation total*.

EQUATION, in Algebra, is an Equality between one Number or Quantity, and one; ſeveral, and one; ſeveral and ſeveral, or between their Sums, Differences, Products, Quotients, Powers and Roots, either all expreſſed particularly by the common Numerical Characters, or univerſally by the Letters of the Alphabet, or by both theſe together, accompanied with the proper Signs $+$, $-$, $\times$, $\div$, $\sqrt{\ }$, &c. and known by this Mark $=$, amongſt them, ſignifying that Number or literal Quantity, or all the Numbers, or literal Quantities, or both, before it, to be equal to the Number or literal Quantity, or all the Numbers or literal Quantities, or both, which are after it. Thus $2 = 2$, $5 + 3 - 2 = 8 - 4 + 2$, $7 = 2 - 1 + 3 + 3$, $a = a$, $b = c$, $dd = gg + hh$, $xx + ax = bb$, $x^3 + ax^2 + bx = c^3$, $\frac{bx^3}{c} + \frac{ex^2}{f} = \sqrt[3]{a^6}$, &c. are all Equations, ſignifying reſpectively that 2 is equal to 2, that $5 + 3 - 2$ (*viz.* 6.) is equal to $8 - 4 + 2$ (*viz.* 6.), 7 equal to $2 - 1 + 3 + 3$, (*viz.* 7.); a equal to a, b equal to c, dd equal to $gg + hh$, $xx + ax$ equal to bb, $x^3 + ax^2 + bx$ equal to c^3, $\frac{bx^3}{c} + \frac{ex^2}{f}$ equal to $\sqrt[3]{a^6}$. You will alſo ſee frequently Numbers or literal Expreſſions of Quantities, or a Mixture of both, before the Sign $=$ of Equality, and a Cypher 0 after it, or elſe a Cypher before and thoſe after, which by many is call'd an Equation. But I think very wrongly, for all that is really meant by ſuch an Expreſſion is, that the Quantities before or after ſuch a Sign mutually, deſtroy each other: Or, when ſome of them be taken from the others, there will be no Difference remaining.

Perhaps the calling ſuch an Expreſſion an Equation, might have given occaſion for the Author of the *Minute Philoſopher*, in his Diſcourſe called *The Analyſt*, pag. 86. *quære* 40. not only to talk Nonſenſe himſelf, but charge the Mathematicians of the preſent Age to do ſo too. *For*, ſays he, *is it not a general Caſe, or Rule, that*

that one and the ſame Co-efficient dividing equal Products, gives equal Quotients? And yet, *whether ſuch Co-efficient can be interpreted by* o, *or nothing, or whether any one will ſay that if the Equation* $5\times 0 = 2\times 0$ *be divided by* o, *the Quotient on both Sides will be equal? Whether therefore a Caſe may not be general, with reſpect to all Quantities, and yet not extend to Nothings, or include the Caſe of nothing; and whether the bringing nothing under the Notion of Quantity, may not have betray'd Men into falſe reaſoning?* Now herein he talks both ignorantly and unintelligibly, and falſely; for in the firſt place, a *Co-efficient* does not divide Products, but multiplies them, as any one that is acquainted with its Definition very well knows. In the next place, whoever calls o, or nothing, a Co-efficient? This would be talking ſtark nonſenſe, ſaying nothing is ſomething. Thirdly, what Mathematician (except this pretended one) ever called $2\times 0 = 5\times 0$, an Equation? Or, would ſay, if it were divided by o, the Quotient on both ſides will be equal. Fourthly, Does his aſking, *whether a Caſe may not be general and extend to all Quantities, and yet not extend to Nothings, or include the Caſe of nothing*, ſignify any more than ſaying a Caſe may be general, and extend to all Quantities; but it is no caſe at all, when there is nothing to make it one. Laſtly, whoever brought nothing under the Notion of Quantity; this would be a Contradiction in Terms: What muſt one take a Man to be, who aſſerts that nothing is ſomething? For Quantity is allowed by all to be ſomething; and of all People, I am very ſure, no Mathematician will ever ſay this is nothing.

The Nature of Equations are very well explained from their Generation; as if x be $=a$, or $x-a=0$, and $x=b$, or $x-b=0$, then will $\overline{x-a}\times\overline{x-b}=0$, be a quadratic Equation, having two affirmative Roots $+a$, and $+b$. In like manner, when $x=a$, $x=b$, $x=c$, or $x-a=0$, $x-b=0$, $x-c=0$; then will $\overline{x-a}\times\overline{a-b}\times\overline{a-c}=0$ be a cubic Equation, having three affirmative Roots. See more of this in *Harriot*'s *Praxis Artis Analyticæ*, (who was the firſt that explained the Nature of Equations after this way,) *Deſcartes*'s *Geometry*, and other Writers of Algebra.—*Vieta* has explained their Nature from the Analogy of their Terms; and Dr. *Barrow*, at the End of his Geometrical Lectures, has given a Specimen of doing the ſame by curve Lines.

Every Equation has as many Roots as the unknown Quantity of the firſt Term has Dimenſions, or as the Exponent thereof contains Units.

All Equations have as many affirmative Roots as there are Permutations of Signs; and as many negative Roots, as there are Succeſſions of them; as in the quadratic Equation $x^2+x-6=0$, there is one Succeſſion of Signs $++$, and one Permutation $+-$. But the Equation has two Roots; one being the affirmative one $+2$, and the other the negative one -3. Alſo in the cubic Equation $x^3-3x^2-10x+24=0$ there are two Permutations of Signs $+-$ and $-+$, and one Succeſſion $--$. But it has three Roots; two affirmative ones $+2$, $+4$, and one negative one -3.

EQUATION (ANNUAL) of the mean Motion of the Sun, and Moon's Apogee and Nodes.

The Annual Equation of the mean Motion of the Sun, depends upon the Eccentricity of the Earth's Orbit round him, and is ſixteen $\frac{11}{12}$ ſuch Parts, of which the mean Di-

 ſtance

ſtance between the Sun and Earth is a thouſand; from whence, by ſome, 'tis called the *Equation of the Centre*; and this, when greateſt, is 1 deg. 56 min. 20 ſec. the greateſt Annual.

EQUATION *of the Moon's mean Motion*, is 11 min. 40 ſec. of its Apogee 20 min. and of its Node 9 min. 30 ſec. and theſe four Annual Equations are always mutually proportionable to one another; ſo that when any of them is at the greateſt, the three others alſo will be greateſt; and when any one leſs, the reſt diminiſh in the ſame Ratio: Whereſore, the Annual Equation of the Centre (of the Sun) being given, the other three correſponding Equations will be given; ſo that one Table (*i. e.* of the Central Equation) may ſerve all.

EQUATION *of a Curve*, is an Equation ſhewing the Nature of a Curve by Expreſſion, the Relation between an Abſciſs, and a Correſpondent Ordinate, (which was firſt done by *Deſcartes* in his Geometry) or elſe expreſſing the Relations of their Fluxions, *&c.* See Sir *Iſaac Newton*'s Fluxions, *&c.*

EQUATION *of Time*, is a Space of Time to be added to, or ſubtracted from the Time ſhewn by the Sun, that thereby it may become equable, and is the Difference between the Sun's mean Motion, and its right Aſcenſion; and is greateſt about the latter End of *January* and *October*, it being then near fifteen Minutes; and about the Beginning of *April*, *June*, and towards the latter End of *Auguſt*, it is leaſt, being then leſs than a Minute. See the Aſtronomical Writers upon this Subject.

EQUATOR. See *Equinoctial*.

EQUICRURAL. See *Iſoſceles*.

EQUICULUS, or EQUUS MINOR, a Conſtellation in the Northern Hemiſphere, conſiſting of four Stars.

EQUILATERAL HYPERBOLA, is ſuch an one whoſe tranſverſe Diameter is equal to its Parameter; and ſo all the other Diameters equal to their Parameters, and the Aſymptotes of it do cut one another at right Angles in the Centre.

Its moſt ſimple Equation, with regard to the tranſverſe Axis, being $yy = xx - aa$; and with regard to the Conjugate $yy = xx + aa$, when a is the Semi-tranſverſe, or Semi-conjugate Axis. The Length of the Curve cannot be found by means of the Quadrature of any Space, of which a Conic Section is any Part of the Perimeter; altho' Mr. *Leibnitz*, in one of his Letters to Sir *Iſaac Newton*, publiſhed in the *Commercium Epiſtolicum*, is of opinion it could. See concerning the Deſcription of this Curve under the word *Hyperbola*.

EQUILATERAL TRIANGLE. See *Triangle*.

EQUILIBRIUM, in Mechanics, is when the two Ends of a Ballance hang ſo exactly even and level, that neither doth aſcend or deſcend, but do both keep in a Poſition parallel to the Horizon, which is occaſioned by their being both charged with an equal Weight.

EQUIMULTIPLES, are Numbers or Quantities multiplied by one and the ſame Number or Quantity. See *Proportion*.

EQUINOCTIAL, (in the Heavens) or Equator on the Earth, is a great Circle, whoſe Poles are the Poles of the World. It divides the Globe into two equal Parts, that is, the Northern and Southern Hemiſpheres. It paſſes through the Eaſt and Weſt Points of the Horizon; and at the Meridian is raiſed as much above the Horizon as the Complement of the Latitude of the Place.

1. Whenever the Sun cometh to this Circle, it maketh equal Days and Nights all round the Globe, be-

cause he then always rises due East, and sets due West, which he doth at no other time of the Year: whence it hath its Name. All Stars also which are under this Circle, or which have no Declination do always rise due East, and set full West, &c.

2. All People living under this Circle (which, in Geography, is called the Line,) have their Days and Nights equal. At Noon the Sun is in the Zenith, or directly over their Heads, and casts no Shadow.

3. From this Circle (on the Globe) is the Declination, or Latitude accounted on the Meridian.

4. And the Circles which run through each Degree of Latitude or Declination, are called *Parallels of Latitude*, or *Declination*.

5. Through this Equinoctial all the Hour-Circles are drawn at right Angles to it; and through the Poles of the World, at every fifteenth Degree on the Celestial Globe.

6. And the Equator on the Terrestrial Globe is divided by the Meridians into thirty-six equal Parts.

7. The natural Day is measured by the Revolution of the Equator, and is ended when the same Point of the Equator comes again to the same Meridian, which is in twenty-four Hours.

8. Wherefore, since the Equator (as all great Circles are) is divided into three hundred and sixty Degrees, each Hour must be $\frac{1}{24}$ of that Number, or fifteen Degrees; therefore one Degree of the Equator will contain four Minutes of an Hour, and fifteen Minutes of a Degree will make a Minute of an Hour, or sixty Seconds; and consequently four Seconds answer to one Minute of a Degree.

EQUINOCTIAL COLURE. See *Colure*.

EQUINOCTIAL DIAL, is one whose Plane is parallel to the Equinoctial.

1. The Hour-Lines on this Dial are all equally distant from one another round the Periphery of a Circle, and the Style thereof is a straight Pin, or Wire, set up in the Centre of the Circle, perpendicular to the Plane of the Dial.

2. The Sun shines upon the upper Part of this Dial-Plane from the 10th of *March* to the 12th of *September*, and upon the under Part the other half of the Year.

3. There are some of these Dials made of Brass, &c. and set up in a Frame, to be elevated to any given Latitude.

EQUINOCTIAL ORIENT. See *Orient*.

EQUINOCTIAL OCCIDENT. See *Occident*.

EQUINOXES, are the precise Times in which the Sun enters into the first Points of *Aries* and *Libra*; for the Sun moving exactly under the Equinoctial, he makes our Days and Nights equal. This he doth twice a Year, about the 10th of *March* and 12th of *September*; which therefore are called the *Vernal* and *Autumnal Equinoxes*.

1. It is found by Astronomical Observation, that the Equinoctial Points (which are the first Points of the Signs *Aries* and *Libra*) go backwards every Year 5 sec.

2. And our admirable Sir *Isaac Newton*, taking the Matter into Consideration, according to his Principles, found, by Calculation, that they must recede 49 min. 58 sec. which is surprisingly near the Truth.

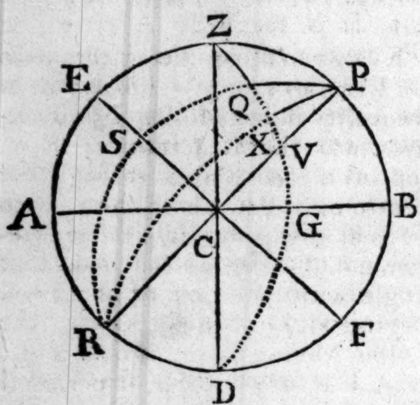
3. The Space from the Vernal to the Autumnal Equinox, is eight or nine Days longer than from the Autumnal to the Vernal, by reason of the Position of the Perihelion of the Earth's Orbit near the Winter Solstice.

Equinus Barbatus, a kind of Comet. See *Hippeus*.

Erect Declining Dials. See *Declining Erect Dials*.

In Dials of this kind, as the Radius is to the Co-ſine of the Plane's Declination, ſo is the Co-ſine of the Elevation of the Pole, to the Sine of the Style's Height. And as the Radius is to the Sine of the Plane's Declination, ſo is the Co-Tangent of the Elevation of the Pole, to the Tangent of the Subſtyle's Diſtance from the Meridian; and as the Radius is to the Co-Tangent of the Declination, ſo is the Sine of the Elevation of the Pole to the Co-Tangent of the Inclination of the Meridians; and as the Radius : is to the Sine of the Style's Height : : ſo is the Tangent of any Hour-Angle : to the Tangent of the Hour-Arch.

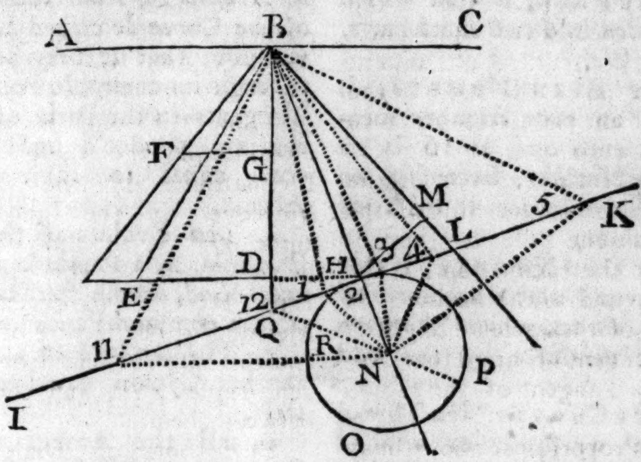
All the Proportions above may be obtain'd from the Doctrine of Spherical Triangles, and that after the following manner: Let A B be the Horizon, E F the Equator, making an Angle with the ſame equal to the Complement of the Latitude.



D Z the prime Vertical, A Z P D the Meridian, P R the Axis of the World and Hour-Circle of Six, in a given Latitude B P. Z G D an Azimuth Circle, upon the Plane of which an erect declining Dial is to be drawn. Let R S P be an Hour-Circle, and R X P another at right Angles to the Azimuth Circle Z G D. Then in the right-angled ſpherical Triangle Z X P, Z X will be the Subſtyle's Diſtance from the Meridian, which may be had by having given the Hypotheneuſe Z P, being the Complement of the Latitude, and the Angle X Z P, being the Complement of the Plane's Declination, the Side P X will be the Style's Height, and the Angle Z P X the Inclination of the Meridians. Moreover, in the ſpherical Triangle Z P Q, the Side Z Q, will be the Angle that the given Hour-Line R S Q P makes with the Meridian at the Centre of the Dial; and this may be had from the given Angles Z, P, and the Side Z P between them.

Theſe Sort of Dials may be drawn geometrically too, the Height of the Style being firſt given. Suppoſe A B C to be an horizontal Line, and the Line B D at right Angles to it, to be the Meridian or Hour-Line of 12. Make the Angle E B D equal to the Complement of the Latitude, and the Angle F B G equal to the Declination of the Plane, and draw E D perpendicular to the Meridian. Make F B equal to E D, and from F let fall F G perpendicular to the Meridian B D, and make D H equal to F G; and thro' B draw B H, which will be the ſubſtylar Line. This done, draw the Line I K thro' H perpendicular to B H, and this will be the Tangent or Contingent Line, as it is called, and make the Angle H B L equal to the Height of the Style, and from H let fall the right Line H M perpendicular to the Style B L. Laſtly, make H N equal to H M, and about the Centre N deſcribe a Circle H R O P; which will be the Equinoctial.

noctial. Continue down the Meridian D B to cut the Tangent Line I K in the Point Q; and draw the right Line Q N, cutting the Equinoctial in R. Then if the Circumference of this Circle be divided into 24 equal Parts, beginning at R, and right Lines be drawn from N thro' them to cut the Tangent I K, in the Points 11, 1, 2, 3, 4, 5, *&c.* and if thro' these last Points be drawn the right Lines B 11, B 1, B 2, B 3, B 4, B 5, *&c.* these will be the Hour-Lines of 11, 1, 2, 3, 4, 5, *&c.*



Erect Direct Planes, or Dials, are those that stand upright, and face the four Cardinal Points.

Erect Direct, East, West, South, or North Dials. See *Erect Direct Planes.*

Eridanus, or Radus, a Southern Constellation, consisting of twenty-eight Stars.

Escalade, or Scalade, is a furious Attack upon a Wall, or Rampart, carried on with Ladders to mount up upon it, without going on in Form, breaking Ground, or carrying on of Works to secure the Men.

Espaule, or Epaule. See *Epaule.*

Espaulement. See *Epaulement.*

Esplenade, a Term in Fortification, the same with the Glacis of the Counterscarp originally; but now 'tis usually taken for the empty Space between the Glacis of a Citadel, and the first Houses of the Town.

Estival Occident. See *Occident.*

Estival Orient. See *Orient.*

Estival Solstice. See *Solstice.*

Evection, or (being the same as) Libration *of the Moon,* is an Inequality in her Motion, by which, at or near the Quadratures, she is not in a Line drawn through the Centre of the Earth to the Sun, as she is at the Syzygies, or Conjunction and Opposition, but makes an Angle with that Line of about two Degrees fifty-one Minutes.

The Motion of the Moon about its Axis is only equable, it performing its Revolution exactly in the same time as it rolls round the Earth; and thence it is that it nearly always turns the same Face towards us. But this Equality, and the unequal Motion of the Moon in her Ellipsis, is the cause why the Moon,

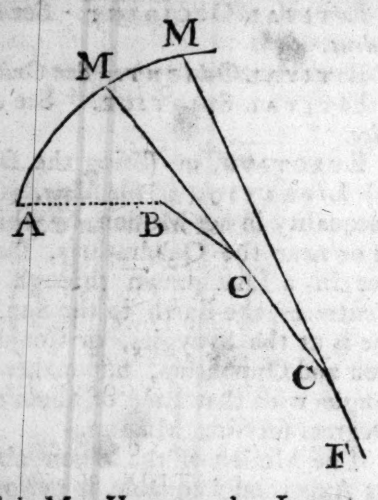
Moon, seen from the Earth, appears to librate a little upon its Axis, sometimes from East to West, and sometimes from West to East; and some Parts in the Eastern Limb of the Moon go backwards and forwards a small Space, and some that were conspicuous, are hid, and then again appear.

Even Number, is that which can be divided into two equal Parts, as 4, 6, 8, *&c.*

Evenly Even Number, is that which an even Number measures by an even one, as 16 is an evenly even Number, because 8, an even Number, measures it by two, an even Number.

Evenly Odd Number, is that which an even Number measures by an odd one, as 20, which the even Number 4 measures by the odd one 5.

Evolute Curves. If a Thread FCM be wrapped, or winded about the Curve BCF, and then unwinded again, the Point M thereof will describe the Curve AMM,



which Mr. *Huygens*, the Inventor, calls a *Curve describ'd from Evolution*; and the Curve BCF is the Evolute, the Part MC of the Thread being called the *Radius of the Evolute.*

1. When the Point B falls in A, the Radius MC of the Evolute is equal to the Arch BC; but if not, to AB + the Arch BC.

2. The Radius of the Evolute CM is perpendicular to the Curve AM.

3. Because the Radius MC of the Evolute continually touches it, it is evident, from the Generation of the Curve described from the Evolution, that it may be described through innumerable Points, if the Tangents in the Parts of the Evolute are produc'd until they become equal to their answerable Arches.

4. The Evolute of the common Parabola, is a Parabola of the second kind, whose Parameter is $\frac{27}{16}$ of the common Parabola.

5. The Evolute of a Cycloid, is another Cycloid equal and similar to it.

6. All the Arches of Evolute Curves are rectifiable, if the Radii of the Evolute can be expressed geometrically.

This Doctrine of Evolute Curves is very well explained and handled by Mr. *Huygens*, in his *Horologium Oscillatorium.* See also what Dr. *James Gregory*, Mr. *Mac-Laurin*, and Sir *Isaac Newton* in his Fluxions, have wrote upon this Subject.

Evolution, in Algebra, signifies the Extractions of the Roots of any Powers.

Eurithmy, in Architecture, is the exact Proportion between all the Parts of any Building.

Eustyle, is the best manner of placing Columns, with regard to their Distance, which *Vitruvius* will have to be two Diameters and a Quarter, or four Modules.

Exagon, the same with *Hexagon.* Which see.

Exhalation, is any thing that is raised up from the Earth by Heat;

Heat; as Vapours, Mists, Fogs, &c.

Exhausted Receiver, is the Vessel of Glass, &c. that stands upon the Body of the Air Pump, in order to have the Air pump'd out of it.

Exhaustions, or the *Method of Exhaustions*, is the ancient Method of *Euclid*, *Archimedes*, &c. that proves the Equality of two Magnitudes by a Deduction *ad Absurdum*, in supposing, that if one be greater or less than the other, there would follow an Absurdity; and it is founded upon the first Proposition of the 10th Book of *Euclid*. See more of this Method in *Prop.* 2, 10, &c. *lib.* 12. *Euclid.*

Exponent *of a Ratio*, is the Quotient arising from the Division of the Antecedent by the Consequent; as the Exponent of the Ratio of 3 to 2 is $1\frac{1}{2}$, and of the Ratio of 2 to 3 is $\frac{2}{3}$. And a Row of Numbers in an Arithmetical Progression, beginning from 0, being placed over a Rank of geometrical Progressionals are called *Exponents*.

1. If the Consequent be Unity, the Antecedent itself is the Exponent of the Ratio.

2. The Exponent of a Ratio is to Unity, as the Antecedent is to the Consequent.

Altho' the Quotient of the Division of the Antecedent by the Consequent, is usually taken for the Exponent of a Ratio; yet in reality, the Exponent of a Ratio ought to be a Logarithm. And this seems to be more agreeable to *Euclid*'s Definition of Duplicate and Triplicate Ratio's in his 5th Book, than Quotients. For 1, 3, and 9, are continual Proportionals; now if $\frac{1}{3}$ be the Exponent of the Ratio of 1 to 3, and $\frac{3}{9}$ or $\frac{1}{3}$, the Exponent of the Ratio of 3 to 9, and $\frac{1}{9}$ the Exponent of the Ratio of 1 to 9; and since *Euclid* says, If three Quantities be proportional, the Ratio of the first to the third is said to be the *Duplicate* of the Ratio of the first to the second, and of the second to the third; therefore, according to this, $\frac{1}{9}$ must be the double of $\frac{1}{3}$, which is very false. But every one knows the Logarithm of the Ratio of 1 to 9; that is, the Logarithm of 9, is the double of the Ratio of 1 to 3, or 3 to 9; that is, the Logarithm of 3. From whence it appears, that Logarithms are more properly the Exponents of Ratios, than numerical Quotients; and of this opinion seem Dr. *Halley*, Mr. *Cotes*, and others.

Exponential Calculus. See *Calculus Exponentialis.*

Exponential Curve, is that whose Nature is expressed by an exponential Equation.

The Area of any exponential Curve, whose Nature is expressed by this exponential Equation, $x^x = y$, (making $1 + v = x$,) will be

$$\frac{1}{0.1.2.} v^2 + \frac{1}{0.1.2.3.} v^3 - \frac{1}{0.1.2.3.4.} v^4 + \frac{1}{0.1.2.3.4.5.} v^5 - \frac{1}{0.1.2.3.4.5.6.} v^6 \text{ \&c.}$$

Exponential Equation, is that wherein there is an exponential Quantity; as $x^x = y$.

Exponential Quantity, is a Quantity whose Power is a variable Quantity; as x^x, a^x.

Exterior Polygon. See *Polygon Exterior.*

Exterior Talus. See *Talus.*

Extermination *of the unknown Quantity from an Equation*, is the taking it away, or getting it out of the Equation.

If there be two Equations, and an unknown Quantity in each of them; has but one Dimension, it may be exterminated by making an Equality

lity between its different Values found in each of them; as if $a+x$ be $=b+y$, and $cx+dy=4g$; then in the first Equation $x=b+y-a$, and $x=\frac{4g-dy}{c}$. And then will $b+y-a=\frac{4g-dy}{c}$; wherein x is exterminated.

If the Quantity to be exterminated be of one Dimension in one of the Equations, and in the other it has more, substitute its Value in the other Equation; as if $xyy=a^3$, and $x^3+y^3=bby-aax$: Then in the first Equation $x=\frac{a^3}{yy}$, and this Value being put for x in the second, and it will be $\frac{a^9}{y^6}+y^3=bby-\frac{a^5}{yy}$; wherein x is gotten out.

When in neither of the two Equations the unknown Quantity to be exterminated does consist of one Dimension, the Value of the greatest Power of it must be found in each Equation; and if those Powers be not the same, the Equation having the least Power, must be multiplied by the Quantity to be exterminated, or by its Square, or Cube, &c. till it has the same Power with that in the other Equation; then an Equality must be made between the Values of those Powers, by which means a new Equation will arise, wherein the greatest Power of the Quantity to be exterminated will be diminished, and by a Repetition of the Operation will at length be exterminated; as if $xx+ax=byy$ and $axy-cxx=d^3$. And x be to be exterminated, in the first Equation xx will be $=byy-aa$, and in the latter $xx=\frac{axy-d^3}{c}$; and so $byy-ax=\frac{axy-d^3}{c}$. Wherein x is reduced to one Dimension, and so may be taken away, from what has been already said. In like manner, if $y^3=xyy+abx$, and $yy=xx-xy+cc$; in order to take out y, the last Equation must be multiplied by y; then will $y^3=yxx-xyy+ccy$ have the same Dimension in both; and so $xyy+abx=yxx-xyy+ccy$, wherein y is brought down to two Dimensions. Then by means of this and the most simple of the given Equations $yy=xx-xy+cc$, we may get out y entirely by what has been already said.

If there be several Equations, and as many unknown Quantities, the Business of exterminating an unknown Quantity must be performed gradually; as if $ax=yz$, $x+y=z$, and $5x=y+3z$. If the Quantity y be made choice of, the Value $\frac{yz}{a}$ of one of the other Quantities x or z, suppose x (found by the first Equation) must be substituted for it in the second or third Equation; by which means we shall obtain $\frac{yz}{a}+y=z$, and $\frac{5yz}{a}=y+3z$. From whence at last z may be taken away, as above.

When the unknown Quantity is of several Dimensions, it is sometimes very troublesome to get it out, and the Labour will be very much shorten'd by the following Examples, being as so many Rules.

1. From $axx+bx+c=0$, and $fxx+gx+h=0$, being exterminated, there comes out $\overline{ah-bg-2cf}\times\overline{ah+bb-cg}\times\overline{bf+agg-cff}\times c=0$.

2. From $ax^3+bxx+cx+d=0$, and $fxx+gx+h=0$, x being exterminated, there comes

comes out $\overline{ab - bg - 2cf} \times abb +$ $\overline{bb - cg - 2df} \times bfh + \overline{ch - dg}$ $\times \overline{agg + cff} + \overline{3agh + bgg + dff}$ $\times df = 0$.

3. From $ax^4 + bx^3 + cxx + dx + e = 0$, and $fxx + gx + h = 0$, x being exterminated, there comes out $\overline{ah - bg - 2cf} \times$ $\overline{ah^3 + bb - cg - 2df} \times bfhh +$ $\overline{agg + cff} \times \overline{chh - dgh + egg -}$ $\overline{2efh + 3agh + bgg - dff} \times$ $dfh + \overline{2ahh + 3bgh - dfg + eff}$ $\times eff - bg - 2ah \times efgg = 0$.

4. From $ax^3 + bxx + cx + d = 0$, and $fx^3 + gx^2 + hx + k = 0$, x being exterminated, there comes out $\overline{ah - bg - 2cf}$ $\times \overline{aahh - achk} + \overline{ak + bh - cg - 2df}$ $\times bdfh \overline{- ak + bh + 2cg + 3df}$ $\times aakk : + \overline{cdh - ddg - cck +}$ $2bdk \times agg + cff : + \overline{3agh}$ $\overline{+ bgg + dff - 3afk} \times \overline{ddf -}$ $\overline{3ak - bh + cg + df} \times bcfk + bk$ $\overline{- 2dg} \times bbfk : \overline{- bbk - 3adh - cdf}$ $\times agk = 0$,

For Example, to exterminate x out of the Equations $xx + 5x - 3yy = 0$, and $3xx - 2xy + 4 = 0$: I respectively substitute in the first Rule for abc, fg, and h, [these Quantities, *viz.*] 1, 5, $-3yy$; 3, $-2y$ and 4; and duly observing the Signs $+$ and $-$, there arises $\overline{4 + 10y + 18yy} \times 4 +$ $\overline{20 - by^3} \times 15 + \overline{4yy - 27yy}$ $\times - 3yy = 0$, or $16 + 40y + 72yy + 300 - 90y^3 + 69y^4 = 0$.

In like manner that y may be gotten out of the Equations $y^3 - xyy - 3x = 0$, and $yy + xy - xx + 3 = 0$, I substitute in the second Rule for a,b,c,d,f,g,h, and x, [these Quantities] $1, -x, 0, -3x$; $1, x, -xx, +3$, and y respectively, and there comes out $\overline{3 - xx + xx}$ $\overline{\times 9 - 6xx + x^4 - 3x + x^3 + 6x} \times$ $\overline{-3x + x^3} : + 3xx \times xx + \overline{9x - 3x^3}$ $\overline{- x^3 - 3x} \times - 3x = 0$. Then blotting out the superfluous Quantities, and multiplying, you have $27 - 18xx + 3x^4, - 9xx + x^6, + 3x^4 - 18x^2 + 12x^4 = 0$. And ordering (duly) $x^6 + 18x^4 - 45xx + 27 = 0$.

These Rules, to be found in Sir *Isaac Newton*'s *Algebra*, may be carried higher at pleasure; but then their Investigation becomes very troublesome. However there have been some Persons, who have been at the pains to compute a general Rule for the Extermination of the unknown Quantities from Equations, wherein they have any Dimensions whatever. But the Application of the Rule to particular Cases, is oftentimes more tedious than their Investigation by the common way.

Sir *Isaac* has not shewn how he found them out; because that follows so easily from what has been said: For Example, in the first Rule, we have $xx + \frac{bx}{a} + \frac{c}{a} = 0$, and $xx + \frac{gx}{f} + \frac{h}{f} = 0$. Therefore $\frac{bx}{a} + \frac{c}{a} = \frac{gx}{f} + \frac{h}{f}$; and so $x = \frac{ah - cf}{bf - ag}$. And if this Value of x be put in the Equation $axx + bx + c = 0$; we shall have $\frac{a^3hh - 2aacfh + accff}{\overline{bf - ag} \times \overline{bf - ag}} + \frac{abh - bcf}{bf - ag} + c = 0$; which E-

quation

quation being clear'd of Fractions, and then contracted as much as possible will become $\overline{ab - bg - 2cf} \times \overline{ab + bh - cg \times bf} + \overline{agg + cff} \times c = 0$. After the same way, altho' with increasing Trouble, the other three Rules may be investigated. If I remember right, *Rhonane* in his Algebra has done this.

EXTERNAL ANGLES. See *Angles External*.

EXTRA-MUNDANE SPACE, is the infinite void Space, which, by some, is supposed to be extended beyond the Bounds of the Universe; and consequently, in which there is really nothing at all.

EXTRACTION *of Roots*, is the Method of finding the Root of a Number or the Value of an unknown Quantity of an Equation. In most Books of common Arithmetic, you have the manner of extracting the Square and Cube Root of a Number. The Analytical Writers who shew how to do this in Species or Algebra, as well for pure Powers, as adfected Equations, are— *Oughtred*, in his *Key to Mathematics*.— *Vieta*, in his *Tractatus de numerosa Potestatum purarum atque affectarum Resolutione*.— Sir *Isaac Newton*, in the *Commercium Epistolicum*; in his *Fragmenta Epistolarum*, published by Mr. *Jones*.— And in Dr. *Wallis*'s *Algebra*.— *Ozanam*'s *Nouveau Elemens d'Algebre*, lib. 2. p. 267.— *Ralphson*, in his *Analysis Æquationum Universalis*.— Monsieur *de Lagney*. — Dr. *Halley*, in the *Philosophical Transactions*.— Mr. *Colson*, in his *Commentary upon Sir* Isaac Newton's *Fluxions*; and many others.

If z, the Root of any adfected Equation, be supposed to be composed of the Parts $+a$, or $-e$, and if from the Quantity $a+e$, or $a-e$, there be form'd all the Powers of z found in the given Equation, and the numerical Quotients be respectively affix'd to them; and if the Powers to be resolv'd be subtracted from the Sum of the given Parts, and the Difference be call'd $\pm b$; and if, in the next Place, the Sum of all the Co-efficients in the second Column be made equal to s; and lastly, if in the third Column there be put down the Sum of all the Co-efficients, which call t; then will the Root z be nearly $= a + \frac{sb}{ss + tb}$; or $z =$ nearly $a \mp \frac{\frac{1}{2}s \pm \sqrt{\frac{1}{4}ss \mp bt}}{t}$.

If $az + bz^2 + cz^3 + dz^4 + ez^5 + fz^6$, &c. $= gy + hy^2 + iy^3 + ky^4 + ly^5 + my^6$, &c. then will the Root of this infinite Equation be $z = \frac{g}{a}y + \frac{h - bAA}{a}y^2 + \frac{i - 2bAB - cA^3}{a}y^3 + \frac{k - bB^2 - 2bAC - 3CAB^2 - dA^4}{a}y^4$, &c. Where it must be observ'd, that every Capital Letter is equal to the Co-efficient of each preceding Term; as the Letter B is equal to the Co-efficient of $\frac{h - bA^2}{a}$.

1. The Denominator of every Co-efficient is always a.

2. The first Member of each Numerator is always a Co-efficient of the Series $gy + hy^2 + iy^3$, &c. *viz.* the first Numerator begins with the Co-efficient g, the second Numerator with the second Co-efficient h, &c.

3. In every Member after the first, the Sum of the Exponents of the Capital Letters is always equal to the *Index* of the Power to which this Member belongs: Thus, if you

you consider the Capital Letter,

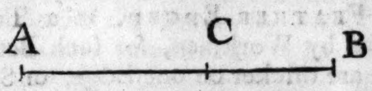
$$\frac{k-bB^2-2bAC-3cA^2B-dA^4}{a},$$

which belongs to the Power y^4, in every Member you will see that bB^2, $2bAC$, $3cA^2B$, dA^4; the Sum of the Exponents of the Capital Letters is 4.

4. The Exponents of the same Letters which are written before the Capitals, express how many Capitals there are in each Member.

5. The Numerical Figures that happen in these Members, express the Number of the Permutations, which the Capital Letters of each Member are capable of.

EXTREME *and* MEAN PROPORTION, is when a Line AB is so divided in C, that the Rectangle



under the whole Line AB and the lesser Segment CB is equal to the Square of the greater Segment AC.

How to divide a right Line after this manner is taught by *Euclid*, in Lib. 2. of his *Elements of Geometry*. But no Number can be so divided into two Parts; as is well demonstrated by *Clavius*, in his Commentary upon Lib. 9. of *Euclid*. This is also evident enough thus: Let a be the Number, and x the greater Part, then the lesser Part will be $a - x$; and so $aa - ax = xx$; and thence $x = \frac{a + a\sqrt{5}}{2}$. And since the square Root of 5 cannot be had in Numbers exactly, it is plain that the Value of x, partly consisting of that square Root, multiplied by a, cannot be had exactly in Numbers neither.

EXTREMES (CONJUNCT,) in right-angled spherical Trigonometry, are the two circular Parts that are next to the middle Part. And

EXTREMES (DISJUNCT,) are the two circular Parts remote from the assumed middle Part. See more of this under *Spherical Trigonometry*.

EYE, an Organ of the Body, representing whatever is visible, and consists of five Tunics, *viz.* the *Cornea*, *Sclerotica*, *Uvea*, *Choroide*, *Retina*: And three Humours, the *Aqueous*, *Crystalline*, and *Vitreous*.

F.

FACE, or FACADE, in Architecture, is a flat Member, which hath a great Breadth, and small Projecture; as in Architraves, &c. It also signifies the Front, or outward Part of a great Building, which immediately presents itself to view.

FACE *of a Bastion*, or, *of the Bulwark*, is the most advanced Part of a Bastion toward the Field, or the Distance comprehended between the Angle of the Shoulder, and the flanked Angle.

FACE *of a Place*, is the Curtain, together with the two Flanks raised above it, and the two Faces of the Bastion that look towards one another, and flank the Angle of the Tenail.

FACE *prolonged*, in Fortification, is that Part of the Line of Defence-Rasant, which lies between the Angle of the Shoulder and the Curtain; or, 'tis the Line of Defence-Rasant diminished by the Length of a Face.

FACIA, *or* FASCIA, signifies any flat Member, as the Band of an Architrave, &c. There are some who write *Fasciæ*, grounded upon the *Latin* Word *Fascia*, a large Turban, which *Vitruvius* makes use of on the like Occasion.

FACTORS, in Multiplication, the Multiplicand and Multiplicator are called

called *Factors*, because they do make or constitute the Product.

FAINT VISION. See *Vision*.

FALCATED. The Moon, or any Planet, is said to appear falcated, when the enlightened Part appears in the Form of a Sickle, or Reaping-Hook, which is when she is moving from the Conjunction to the Opposition, or from New Moon to the Full; but from Full to a New again, the enlightened Part appears gibbous, and the dark falcated.

FALCON. See *Faucon*.

FALCONET. See *Fauconet*.

FALSE ATTACK. See *Attack*.

FALSE BRAYE, in Fortification, is a small Mount of Earth four Fathom wide, erected on the Level round the Foot of the Rampart, on the Side of the Field, and separated by its Parapet from the Berme, and the Side of the Moat. 'Tis made use of to fire upon the Enemy, when he is already so far advanced, that you cannot force him back from of the Parapet of the Body of the Place; and also to receive the Ruins which the Cannons make in the Body of the Place.

FALSE POSITION. See *Position*.

FASCIA. See *Facia*.

FASCIÆ, *from Bands, or Swathes*, are certain Places in the Disks of the Planets *Mars* and *Jupiter*, that appear lighter, or more obscure than the rest of their Bodies, being terminated by parallel Lines, and seem sometimes broader, and sometimes narrower, and do not always possess the same Place of the Disk.

A very broad, but duskish *Fascia* was observed in the middle of the Planet *Mars* by Mr. *Huygens*, in the year 1656.

FASCINES, *or* FAGGOTS, in Fortification, are small Branches of Trees, or Bavins, bound up in Bundles, which being mixed with Earth, serve to fill up Ditches, to make up the Parapets of Trenches, &c. Some of them are dipped in melted Pitch or Tar, and being set on fire, serve to burn the Enemy's Lodgments, or other Works.

FAUCON, a sort of a Cannon, whose Diameter at the Bore is five Inches and a quarter, Weight seven hundred and fifty Pound, Length seven Foot, Load two Pound and a half, Shot two Inches and a half Diameter, and two Pounds and a quarter Weight.

FAUCONET, a sort of Ordnance, whose Diameter at the Bore is four Inches and a half, Weight four hundred Pounds, Length six Feet, Load one Pound and a quarter, Shot something more than two Inches Diameter, and one Pound and a quarter Weight.

FAUSSE BRAYE. See *False Braye*.

FEATHER-EDGED, is a Term used by Workmen, for such Boards as are thicker on one Edge, or Side, than on the other.

FELLOWS, in Fortification, are six Pieces of Wood, each of which form an Arch of a Circle; and these joined all together by Duledges, make the Wheel of a Gun-Carriage. Their Thickness is usually the Diameter of the Bore of the Gun they serve for, and their Breadth something more.

FELLOWSHIP, or *the Rule of Fellowship*, in Arithmetic, is a Rule that teaches how, by having given the several Stocks of Persons that are Partners together in Trade; to proportion to every one of them his due Share of Loss or Gain.

The Rule of Three, several ways repeated, will fully answer any Question in this Rule.

For as the whole Stock (or general Antecedent) : is to the Total thereby gained or lost, (which is the general Consequent) :: so each Man's particular Share : is to his proper Share of Loss or Gain.

FIBRES, are the small Threads, or Filaments, of which elastic Bodies are, or may be supposed to be made.

1. The Elasticity of Fibres consists in this, that they can be extended, and taking away the Force by which they are lengthened, they will return to the Length which they had at first.

2. Fibres have no Elasticity, unless they are extended with a certain Force.

3. When a Fibre is extended with so much Force, it loses its Elasticity.

4. The Weight by which a Fibre is increased a certain Length by its stretching, is, in the different Degrees of Tension, as the Tension itself.

5. The least Lengthenings of the same Fibres are, to one another, nearly as the Forces by which the Fibres are lengthened. Therefore, in all the least Inflections of a Chord, Musical String, or Wire, the *Sagitta* is encreased and diminished in the same Ratio as the Force with which the Chord is inflected.

6. In Chords of the same Kind, Thickness, and which are equally stretched, but of different Lengths, the Lengthenings, which are produced by superadding equal Weights, are to one another, as the Lengths of the Chords. If the Forces by which the Fibres are stretched be equal, and they are inflected by equal Forces, even in that Case also the *Sagittæ* will be equal, however different the Thickness be.

7. If there be two equal and similar Chords, but unequally stretched, the Squares of the Times of the Vibrations are to one another inversely as the Weights by which the Chords are stretched.

8. Any Chords of the same kind being given, the Durations of the Vibrations may be compared together; for they are in a Ratio compounded of the inverse Ratio of the square Roots of the Weights, by which the Chords are stretched, of the Ratio of the Lengths of the Chords, and of the Ratio of the Diameters.

9. Every Particle of a stretched String or Wire, any how set in motion, and causing Sound, uniformly vibrating backwards and forwards, with a very small Motion, is always accelerated and retarded according to the Law of the Vibration of a Pendulum. The periodical Time of one Vibration, being to the Time of the Descent thro' half the Length of the String by the Force of Gravity, in the subduplicate Ratio of the Weight of the String to the Force stretching it.——And from hence it is computed, that a Musical String, sounding De la Solre, performs 250 Vibrations in a Second of Time.

FICHANT FLANK. See *Flank*.

FICHANT LINE *of Defence*. See *Fixed Line of Defence*.

FIELD-FORT. See *Fortine*.

FIELD-PIECES, are small Cannon, which are usually carried along with an Army in the Field; such as Three Pounders, Minions, Sakers, Six Pounders, Demi-Culverins, and Twelve Pounders; and these being small and light, are easily carried.

FIELD-STAFF, is a Staff carried by the Gunners, being about the Length of a Halbert, with a Spear at the End, which to each Side has Ears screw'd on like the Cock of a Matchlock; and the Gunners screw lighted Matches in these when they are on Duty, this being called *Arming the Field Staff*.

FIFTH, a Term in Music, being the same as *Diapente*. Which see.

FIGURAL (or FIGURATE) NUMBERS, are such as do, or may represent some Geometrical Figure, in relation to which they are always consider'd; as triangular Numbers, Pentagonal Numbers, Pyramidal

Numbers, &c. Of which see more under the respective Words.

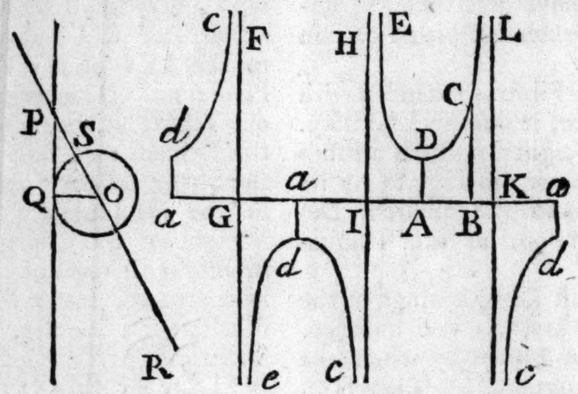
FIGURATIVE DISCANT. See *Discant*.

FIGURE, in Physics, or Natural Philosophy, is the Surface or terminating Extremes of any Body.

FIGURE, in Conic Sections, according to *Apollonius*, is the Rectangle made under the *Latus Rectum* and *Transversum* in the Hyperbola and Ellipsis.

FIGURE, in Geometry, is a Space encompassed round on all Sides, and is either Rectilineal, Curvilineal, or Mixed.

FIGURE *of the Secants*, is a mechanical Curve thus generated: Let P Q be a Tangent to the Circle Q S O, and let an infinite right Line



P O R revolve about the Centre O, cutting the Circle in S, and the Tangent in P: then if upon the infinite Base, or abscissal Line A K, be taken the Point A, and afterwards the Abscis A B be taken upon the same, always equal to the circular Arch Q S, and the correspondent Ordinate B C at right Angles to it, be equal to the Secant O P of that Arch, and moves along A K: By this Motion the Extremity C of that Ordinate will describe the Curve E D C, called the *Figure* of the Secants.

This Curve, in reality, consists of an infinite Number of such Parts; of which E D C is one, having an infinite Number of parallel Asymptotes F G, H I, L K, drawn at Distances from one another, each equal to half the Circumference of the Circle Q S O, which Parts do alternately fall above and below the abscissal Line AK: the least Ordinates being *a d* or A D, each equal to the Radius Q O of the Circle. The reason of this is, because the infinite Secant P O R revolving perpetually about the Centre, round and round again, will be affirmative, and negative by turns, passing from the one to the other as often as it goes through Infinity (speaking in the modern Style:) where it is to be observed, that so much of the Curve as appears in the Figure, is described during the Motion of the Secant, from the Situation Q O, till it has moved once and a half about.

The Quadrature of the Space A D C B will give the meridional Parts for a given Latitude in *Mercator*'s Chart. And this may be obtained by the Quadrature of an hyperbolic Space, or, which is the same thing, by the Logarithms: For if the Circle O Q S be a Meridian, Q a Point of the Equator, and S a Point whose Latitude is Q S, it is well known, that its meridional Parts, or Latitude, is to its true Magnitude,

Magnitude, as the Sum of the Secants ſtanding upon this, is to the Sum of ſo many times the Radius; that is, as the curvilinear Area A B C D, to the Rectangle D A B inſcribed in it. Now if O Q or A D be called r; A B or Q S, x; and B C or O P, y; we ſhall have $\dot{x} = \frac{rr\dot{y}}{y\sqrt{yy-rr}}$, and the Fluxion of the Area A B C D will be $= \frac{rr\dot{y}}{\sqrt{yy-rr}}$: and the Fluent of this Fluxion may be had from the Tables of Mr. *Cotes*'s *Harmonia, viz.* the 6th Form of Fluxions, it being the Logarithm of the Ratio of O Q to O P — P Q, or of Radius to the Tangent of half the Complement of the Latitude, the Radius being the Module (as Mr. *Cotes* calls it) of the Canon of Logarithms; that is, the Number 0.434294481903, *&c.* in *Brigg*'s or *Ulacque*'s Logarithms.

FIGURE *of the Sines*, is a mechanical Curve A C G, generated much after the ſame way as the *Figure* of the Secants, the Difference being only, that here every Ordinate B C, anſwerable to the Abſciſs A B, is the Sine of the correſpondent Arch Q S of the Circle, (ſee the *Figure of the Secants,*) inſtead of being its Secant as O P: This Curve conſiſting of an infinite Number of Parts, ſuch as A C G, alternately riſing above, and falling below the abſciſſal Line A I; which, in reality, make but one continued infinite ſerpentine Line.

Note, Some define this Curve more

generally, by making the ſeveral Ordinates BC, not only equal to the ſeveral Sines, but in a given Ratio to them.

Any Space A B C of this Curve is ſquareable: For ſuppoſing r to be the Radius of the generating Circle, and the Sine or Ordinate B C to be y, the Fluxion of that Area will be $\frac{\dot{y}ry}{\sqrt{rr-yy}}$; and the Fluent of this Fluxion will be $rr - r\sqrt{rr-yy}$; that is, the Space A B C is equal to the Rectangle under the Radius, and the verſed Sine of the Arch of the generating Circle to which the Abſciſs A B is equal; ſo that the Area of the whole Space A C G is equal to twice the Square of the Radius.

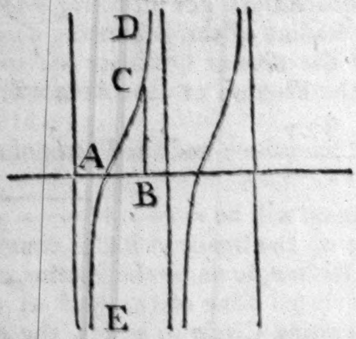
The Curve cannot be rectified even by means of any Space belonging to the conic Sections; for its Fluxion is $\dot{y}\sqrt{\frac{2rr-yy}{rr-yy}}$, and its Subtangent will be $\frac{ry}{\sqrt{rr-yy}}$.

This Curve (as generally defined above) is that, into which a ſtretch'd String or Wire perpetually conforms itſelf, when it is ſet a vibrating by a Quill or other ſmall Force; as eaſily follows from what Dr. *Taylor* has ſaid, concerning the Motion of a ſtretch'd String, in the *Philoſophical Tranſactions*, N° 337.

The firſt who I can find took notice of this Curve, was Father *Fabri*, in his *Synopſis Geometrica*, publiſhed about the year 1669, wherein he gives a Diſcourſe concerning the ſame; and this makes me wonder, why *Wolfius*, in his *Elementa Matheſ. Univerſ.* ſhould attribute the Invention to Mr. *Leibnitz?*

FIGURE *of the Tangent*, is a mechanical Curve E A C D, generated like the *Figure* of the Secants, (ſee above under that Word) with this Difference, that the Ordinate B C is here equal to the Tangent Q P of

of the Arch QS, to which the Abſciſs A B is equal; the Curve



conſiſting of an infinite Number of ſuch Parts, of which E A D is one, and having a like Number of parallel Aſymptotes at equal Diſtances from each other.

FIGURES, in Arithmetic, are the nine Digits, or numerical Characters, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0.

FIGURES CURVILINEAL, are ſuch as have their Extremities crooked; as Circles, Ellipſes, *&c.*

FIGURES MIXED, are ſuch as are bounded partly by right Lines, and partly by crooked ones; as a Semi-circle, Segment of a Circle, *&c.*

FIGURES PLANE, (or *Plane Surfaces*,) are ſuch as are terminated and bounded by right Lines only.

FIGURES RECTILINEAL, are thoſe that have their Extremities all right Lines, as Triangles, Quadrilaterals, *&c.* Polygons regular, irregular, *&c.*

FILLET, is any little ſquare Moulding, which accompanies or crowns a larger.

FINITE, is what hath fixed and determined Bounds or Limits ſet to its Power, Extent, or Duration.

FINITOR, the ſame with the Horizon; and 'tis ſo called, becauſe the Horizon finiſhes or terminates your Sight, View, or Proſpect.

FIRMAMENT, by ſome Aſtronomers, is taken for the Orb of the fixed Stars, or the Height of Heaven. But more properly 'tis that Space which is expanded or appears arched over us above in the Heavens.

FIRST MOVER. See *Primum Mobile.*

FISSURES, are certain Interruptions, that horizontally or parallelly divide the ſeveral Strata, of which the Body of our terreſtrial Globe is compoſed.

FIXED LINE *of Defence*, in Fortification, is a Line drawn along the Face of the Baſtion, and terminates in the Courtin.

FIXED SIGNS *of the Zodiac*, are, by ſome, *Taurus*, *Leo*, *Scorpio*, and *Aquarius*, being ſo called, becauſe the Sun paſſes them reſpectively in the middle of each Quarter, when that particular Seaſon is more ſettled and fixed than under the Sign that begins and ends in it.

FIXED STARS, are ſuch that conſtantly keep at the ſame Diſtance, with reſpect to each other.

1. The firſt who compoſed a Catalogue of the fixed Stars was *Hipparchus* of *Rhodes*, about a hundred and twenty Years before *Chriſt*, who, from his own, and the Obſervations of ſome before him, collected a thouſand and twenty-two Stars, according to their proper Latitudes and Longitudes: And ſo, in *Pliny*'s Judgment, *dared to do a thing which God himſelf did not approve of, in telling the Number of the Stars for Poſterity, and reducing them to a Standard.*

2. *Ptolemy* augmented *Hipparchus*'s Catalogue with four Stars more. And *Ulegbeigh*, the Grandſon of *Tamerlane* the Great, placed a thouſand and ſeventeen in his Catalogue, who ſays in his Preface, That he obſerved all that could be obſerved, beſides twenty-ſeven in the South.

3. The next who made a Catalogue was *Tycho Brahe*, of ſeven hundred

hundred and ſeventy-ſeven fixed Stars, from his own Obſervations; and would admit no Star into his Catalogue, but what he had found out, and inveſtigated by his Inſtruments.

4. Dr. *Halley* was the firſt who obſerved rightly the ſouthern fixed Stars at *St. Helena*, being three hundred and ſeventy-three in Number; and computed their Places for the Year 1677.

5. *Hevelius* of *Dantzic* likewiſe made a Catalogue of the fixed Stars, containing one thouſand eight hundred and eighty eight in all, *viz.* nine hundred and fifty known by the Antients, and ſix hundred and three, which he calls his own, and three hundred and thirty-five of Dr. *Halley*'s, which could not be ſeen in the Horizon of *Dantzic*.

6. But Mr. *Flamſtead*'s Catalogue of Stars, contain'd in his *Hiſtoria Cœleſtis*, is far more numerous and exact than any of the others; for it contains three thouſand Stars; but many of them cannot be obſerved without a Teleſcope; ſo that you cannot obſerve above a thouſand by the naked Eye in the viſible Hemiſphere: And this ſeems wonderful to many, that in a ſerene Night, when the Moon does not ſhine, at firſt ſight the Stars appear to be innumerable: But this proceeds from the Fallaciouſneſs of Viſion, proceeding from the vehement Twinkling of the Stars, while the Eye obſerves them all together confuſedly, and without Order.

7. Yet the Number of the fixed Stars, obſervable by a Teleſcope, is vaſtly great; for direct a good Teleſcope to the Heavens, and there will appear great Multitudes, eſpecially in the *Via Lactea*.

8. Dr. *Hook*, with a Teleſcope of twelve Feet, obſerved ſeventy eight Stars in the *Pleiades*; and with longer Teleſcopes he ſtill found out more. And *Anthony Maria de Rheita* affirms, that in the ſingle Conſtellation of *Orion*, he number'd above two thouſand Stars, by help of a Teleſcope.

9. Several fixed Stars, obſerved by the Ancients, vaniſh, or cannot now be ſeen; and new ones appear for a time, and then vaniſh. The Light of ſome Stars alſo diſappear, and after a ſtated Period they ſhine again: Among which is that eminent one in the *Neck of the Whale*, which for eight or nine Months is not ſeen; and the other four or three Months it appears, varying its Magnitude.

10. The fixed Stars, like the reſt of the Planets, appear every Day to riſe and ſet, and to move with a circular Motion from Eaſt to Weſt in twenty four Hours, in Circles whoſe Planes are parallel to the Equator.

11. The fixed Stars, beſides their former apparent Motion round the Earth, ſeem to have another quite contrary to that. By this they appear to change their Longitude, or Diſtance, from the Beginning of *Aries* forward, according to the Order of the Signs, or to move *in conſequentia*, by a ſlow Motion of about one Degree in ſeventy Years. So that thoſe Stars, that in *Hipparchus*'s time were in *Aries*, are now in *Taurus*, &c. And the Proceſſion of the Terreſtrial Equinoxes is the Cauſe of this apparent Motion.

12. The Light of the fixed Stars is much more ſtrong and vivid than that of the Planets, altho' their apparent Diameters are much leſs; becauſe the Stars, like the Sun, ſhine by their own Light, and the Planets only by the Reflection of the Sun.

13. The fixed Stars twinkle much more than the Planets; becauſe their apparent Diameters being very ſmall, the leaſt Atom, or Particle of Matter, floating in our Atmoſphere,

ſphere, will hinder, for a Moment, the Stars being entirely viſible; as the thick Smoke of a Chimney will do the Planets themſelves, which will twinkle in ſuch a caſe.

14. The Diſtance of the fixed Stars from us is vaſtly great; becauſe they have no ſenſible Parallax ariſing from the annual Motion of the Earth. Tho' Mr. *Flamſtead* ſays, that the annual Parallax of the Pole-Star is forty Seconds; and Mr. *Huygens* tells us, that with Teleſcopes, which would magnify the apparent Diameter above a hundred times, he could never diſcover any ſenſible Magnitude in the fixed Stars.

FLANK, in Fortification, is that Part of the Baſtion which reaches from the Courtin to the Face, and defends the oppoſite Face, the Flank, and the Courtin.

There is alſo the oblique or ſecond Flank, which is that part of the Courtin, where they can ſee to ſcour the Face of the oppoſite Baſtion; and is the Diſtance between the Lines Raſant and Fichant.

The low, covered or retired Flank, is the Platform of the Caſemate, which lies hid in the Baſtion.

FLANK, is alſo a Term of War, ſignifying one ſide of a Battalion of an Army; as to attack the Enemy in Flank, is to diſcover and fire upon them on one ſide.

FLANK *of the Courtin*, or ſecond Flank, is that part of the Courtin between the Flank and the Point, where the Fichant Line of Defence terminates.

FLANK *a Place*, is to diſpoſe a Baſtion, or other like Work, in ſuch manner, that there ſhall be no part of it, but what is defended; ſo as you may from thence play upon Front and Rear. For any Fortification, that hath no Defence but juſt right forwards, is faulty; and to render it compleat, one Part ought to be made, to flank the other. Hence the Courtin is always the ſtrongeſt Part of any Place, becauſe 'tis flanked at each end.

FLANK (FICHANT,) is that from whence a Cannon playing, fireth its Bullets directly in the Face of the oppoſite Baſtion.

FLANK (RASANT,) is the Point from whence the Line of Defence begins, from the Conjunction of which, with the Courtin, the Shot only razeth the Face of the next Baſtion, which happens when the Face cannot be diſcovered, but from the Flank alone.

FLANK (RETIRED,) or the lower or covert Flank, is that exterior Part thereof, whoſe advanced Part if it be rounded, is called the *Orillon*; ſo that this *Flank Retiré*, as the *French* call it, is only the Platform of the Caſemate, which lies hid in the Baſtion.

FLANKS SIMPLE, are Lines which go from the Angle of the Shoulder to the Courtin, and whoſe principal Function is the Defence of the Moat and Place.

FLANKED (or DOUBLE TENAILLE.) See *Tenaille*.

FLANKED LINE *of Defence*. See *Raſant Line of Defence*.

FLANKING ANGLE. See *Angle*.

FLANKED ANGLE, is the Angle formed by the two Faces of the Baſtion, and ſo forms the Point of the Baſtion.

FLAT BASTION. See *Baſtion*.

FLAT-BOTTOM'D MOAT. See *Moat*.

FLAT CROWN. See *Corona*.

FLIE. That Part of the Mariner's Compaſs on which the thirty two Winds are drawn, and to which the Needle is faſten'd underneath, they call the *Flie*.

FLOATING BRIDGE, is a Bridge made in form of a Redoubt, conſiſting of two Boats, covered with Planks, which ought to be ſo ſolidly framed,

framed, as to bear both Horse and Cannon.

Fluent, or *flowing Quantity* of a *Fluxion*, is that Quantity (whether Line, Surface, Solid, &c.) of which it is the Fluxion; as the Fluent of $\dot{x}$ is x, and the Fluent of $x\dot{y}+y\dot{x}$ is xy; and so of others.

It is easy to find the Fluxions, in all cases of given Fluents, and that exactly; but on the contrary, it is very difficult to find the Fluents of given Fluxions. Indeed there are infinite Cases where these cannot be exactly had, unless by the Quadrature of curve-lin'd Spaces; and since the Areas of Curves in order above the Conic Sections cannot be accurately expressed in Numbers, Analysts have been obliged to be content with Fluents, expressed near the Truth by Series's. This Doctrine was first invented by Sir *Isaac Newton*, and notwithstanding the many Authors upon the Subject after him (except Mr. *Cotes*) he has handled the Business more profoundly, and carried it much farther than any of them, whether *English* or Foreigners. See his *Fluxions*, and *Quadrature* of Curves. See also Mr. *Cotes*'s *Harmonia Mensurarum*.

1. The Fluent of the Fluxion $az^{\pm m}\dot{z}$ will be $\frac{az^{\pm m+1}}{\pm m+1}$.

2. The Fluent of $az^{\pm\frac{m}{n}}\dot{z}$, will be $\frac{an}{\pm m+n}z^{\frac{\pm m+n}{n}}$. 3. The Fluent of $dz^{\theta}\dot{z}\times\overline{e+fz^n}|^m$ (where d, e, f, express any given Quantities, and θ, n, and m, the Indexes of the Powers of the Quantities to which they are affix'd, by making $\frac{\theta+1}{n}=r$, $m+r=s$, $\frac{d}{nf}\times\overline{e+fz^n}|^{m+1}=Q$, and $cn-n=p$:) will be $Q\times\frac{z^p}{s}-\frac{r-1}{s-1}\times\frac{eA}{fz^n}+\frac{r-2}{s-2}\times\frac{eB}{fz^n}\times\frac{eC}{fz^n}+\frac{r-4}{s-4}\times\frac{eD}{fz^n}$, &c. the Letters A, B, C, D, &c. expressing the nearest antecedent Terms, *viz.* A the Term $\frac{z^p}{s}$; B the Term $-\frac{r-1}{s-1}\times\frac{eA}{fz^n}$, &c. This Series where r is a Fraction or negative Number runs on infinitely; but when r is a whole affirmative Number, it becomes finite, consisting of so many Terms as there are Units in r.

The Fluents of the following Forms of Fluxions may be had in finite Terms, *viz.* of $d\dot{z}z^{\theta n-1}\sqrt{e+fz^n}$, when θ is a positive whole Number, and n an whole Number.—Of $d\dot{z}z^{\theta n+\frac{1}{2}n-1}\sqrt{e+fz^n}$, when θ is a negative whole Number.—Of $\frac{d\dot{z}z^{\theta n-1}}{\sqrt{e+fz^n}}$, when θ is a positive whole Number.—Of $\frac{d\dot{z}z^{\theta n+\frac{1}{2}n-1}}{\sqrt{e+fz^n}}$, when θ is a negative whole Number. But when θ is a whole Number, and the Sign thereof is otherwise, the Fluents cannot be had but by the Quadrature of the Hyperbola or Ellipsis, or by the Logarithms or Tables of Sines, or else by infinite Series's: It being an Hyperbola when the Sign of fz^n is $+$, and an Ellipsis when it is $-$. Fluents of the following Terms of Fluxions may be obtained

obtained by the Hyperbola and Ellipsis. 1. $\frac{d\dot{z}z^{\theta n - 1}}{e + fz^n}$.

2. $\frac{d\dot{z}z^{\theta n + \frac{1}{2}n - 1}}{e + fz^n}$.

3. $\frac{d\dot{z}z^{\theta n - 1}\sqrt{e + fz^n}}{g + hz^n}$.

4. $\frac{d\dot{z}z^{\theta n + \frac{1}{2}n - 1}\sqrt{e + fz^n}}{g + hz^n}$.

5. $\frac{d\dot{z}z^{\theta n - 1}}{\overline{g + hz^n} \times \sqrt{e + fz^n}}$.

6. $\frac{d\dot{z}z^{\theta n + \frac{1}{2}n - 1}}{\overline{g + hz^n}\ \sqrt{e + fz^n}}$.

7. $d\dot{z}z^{\theta n - 1}\sqrt{\frac{e + fz^n}{g + hz^n}}$.

8. $\frac{d\dot{z}z^{\theta n - 1}}{k + lz^n}\sqrt{\frac{e + fz^n}{g + hz^n}}$.

9. $\frac{d\dot{z}z^{\theta n - 1}}{e + fz^n + fz^{2n}}$.

10. $\frac{d\dot{z}z^{\theta n - 1}}{\overline{k + lz^n},\ \overline{e + fz^n + gz^{2n}}}$.

11. $d\dot{z}z^{\theta n - 1}\sqrt{e + fz^n + gz^{2n}}$.

12. $\frac{d\dot{z}z^{\theta n - 1}}{\sqrt{e + fz^n + gz^{2n}}}$.

13. $\frac{d\dot{z}z^{\theta n - 1}\sqrt{e + fz^n + gz^{2n}}}{k + lz^n}$.

14. $\frac{d\dot{z}z^{\theta n - 1}}{\overline{k - lz^n},\ \sqrt{e + fz^n + gz^{2n}}}$.

In all these Forms θ is a whole Number, positive or negative.

The Expressions of the Fluents of most of these Forms of Fluxions may be seen in Sir *Isaac Newton*'s Quadrature of Curves; and of all of them in Mr. *Cotes*'s *Harmonia Mensurarum*. From which Treatise we learn, that Mr. *Cotes* could find the Fluent of any Fluxion whose Form might be compared with $\frac{d\dot{z}z^{\theta n + \frac{d}{l}n - 1}}{e + fz_n}$ (where d, e, f, are any given Quantities, and n any Index of the variable Quantity z; θ any affirmative or negative whole Number, and $\frac{d}{l}$ any Fraction,) by means of the Hyperbola and Ellipsis. Moreover, he affirms, that he could find the Fluents of Fluxions of this Form $\frac{d\dot{z}z^{\theta n + \frac{d}{l}n - 1}}{e + fz^n + gz^{2n}}$, or even of this $\frac{d\dot{z}z^{\theta n + \frac{d}{l}n - 1}}{e + fz + gz^{2n} + hz^{3n}}$, without any Exception or Limitation, when θ is a positive or negative whole Number, and l the Denominator of the Fraction $\frac{d}{l}$ is any Number of this Series 2, 4, 8, 16, 32, &c. and seems to be of opinion that the Fluent of any rational Fluxion depends upon the Measure of Ratio's and Angles, or upon Logarithms and the Tables of Sines; those being excepted, that may be had otherwise in finite Terms. And Dr. *Smith*, the ingenious Editor of this Work, says, he could have put down the Fluents of

$\frac{d\dot{z}z^{\theta n - 1}}{e + fz^n + gz^{2n} + hz^{3n} + kz^{4n} + lz^{5n}}$, and

and $\dfrac{d\dot{z}z^{\theta n-1}}{e+fz^n+gz^{2n}+bz^{3n}} \times \overline{\dfrac{k+lz^n}{m+nz^n}}\Big|^{\frac{d}{l}}$, by means of the Measure of Ratio's and Angles; but that he began to be tired with the Calculation.

When an Equation for a Fluent is found, it is very often neceſſary to add to or ſubtract from it ſome invariable Quantity, in order to get the true Fluent, which Quantity is eaſily found by making the variable Quantity in the Expreſſion to vaniſh, and putting what remains, with its Sign changed, to the ſaid Expreſſion, as the Expreſſion $\frac{2}{3}\overline{b+x}\sqrt{ab+ax}$, which the common Rules give for the Fluent of $\dot{x}\sqrt{ab+ax}$, will not be the true Fluent of this Fluxion; it being too much by the Quantity $\frac{2}{3}b\sqrt{ab}$ obtained from $\frac{2}{3}\overline{b+x}\sqrt{ab+ax}$ by making $x=0$; ſo that the true Fluent will be $\frac{2}{3}\overline{b+x}\sqrt{ab+ax} - \frac{2}{3}b\sqrt{ab}$.

The Fluent of a ſimple Fluxion is found by ſtriking out the fluxionary Letter, increaſing the Index of the variable Quantity by 1, and dividing the laſt Expreſſion by the Index thus increaſed; as the Fluent of $a\dot{x}x^m$, will be $\dfrac{ax^{m+1}}{m+1}$, and that of $\dfrac{a\dot{x}}{x^m}$, will be $\dfrac{ax^{-m+1}}{-m+1}$. And the Fluent of a Fluxion conſiſting of any Number of ſimple Terms joined together by the Signs + and —, will be equal to the ſeveral Fluents of thoſe ſimple Terms joined in like manner by the Signs + and —; and the Fluent of a Compound radical or fractional Quantity, will be had, (tho' not exactly in general) by firſt throwing thoſe Expreſſions into infinite Series's of ſimple Terms, and then finding the Fluents of thoſe ſimple Terms.

Fluid Body, is that whoſe Parts yield to any Impreſſion; and by yielding are eaſily moved one among another: And ſo it follows, that Fluidity ariſes from hence, *viz.* that the Parts do not ſtrongly cohere, and that the Motion is not hinder'd by any Inequality in the Surface of the Parts.

1. Fluids agree in this with ſolid Bodies, that they conſiſt of heavy Particles, and have their Gravity proportionable to their Quantity of Matter, in any Poſition of the Parts.

2. The Surface of a Fluid contained in a Veſſel, to keep it from flowing out, if it be not preſſed from above, or if it be equally preſſed, will become plain, and parallel to the Horizon.

3. The lower Parts of Fluids are preſſed by the upper: This Preſſure is in proportion to the incumbent Matter, that is, to the Height of the Liquid above the Particle that is preſſed.

4. The Preſſure upon the lower Parts, which ariſes from the Gravity of the Super-incumbent Liquid, exerts itſelf every way, and every way equally.

5. In Tubes, whether equal or unequal, whether ſtraight or oblique, a Fluid riſes to the ſame Height.

6. When Liquids of different Gravities are contained in the ſame Veſſel, the heavieſt lies at the loweſt Place, and is preſſed by the lighter, and that in proportion to the Height of the lighter.

7. The Bottom and Sides of a Veſſel, which contains a Liquid, are preſſed by the Parts of the Liquid, which immediately touch them.

This

This Action increases in proportion to the Height of the Liquid.

8. When a Solid is immersed in a Liquid, it is pressed by the Liquid on all sides; and that Pressure increases in proportion to the Height of the Liquid above the Solid. Bodies very deeply immersed are equally pressed on all sides.

9. A Body specifically heavier than a Liquid, being immersed in a Liquid, will descend.

10. A Solid specifically lighter than a Liquid, ascends to the highest Surface of the Liquid. But suppose a Solid of the same specific Gravity with the Liquid at any Height; the Liquid will sustain the whole Body.

11. All equal Solids, but of different specific Gravities, when they are immersed into the same Liquid, they lose equal Parts of their Weight.

12. However the Densities of equal Bodies differ among themselves, if they be immersed in the same Liquids, the Weights which they lose are in the Ratio of their Bulks.

13. The immersed Parts of the Bodies swimming on the Surface of the same Liquor, are to one another as the Weights of the Bodies. And the Parts which descend into the Liquid, by laying on of different Weights, are to one another as those Weights.

14. If any Vessel be filled with a Liquid, and that Liquid be weighed, and if you make the same Experiment with other Liquids, their Weights will be as their Densities.

15. All Bodies moved in Fluids suffer a Resistance, which arises from two Causes: The first is the Cohesion of the Parts of the Liquid: The second is the Inertia, or Inactivity of Matter; the Retardation from the Cohesion of Parts is as the Velocity itself. The Resistance arising from the Inertia, or Inactivity of Matter, when the same Body moves through different Liquids with the same Velocity, is as the Density of the Liquid.

16. When the same Body moves through the same Liquid with different Velocities, this Resistance increases as the Square of the Velocity.

17. The Resistance from the Cohesion of Parts in Liquids, except glutinous ones, is not very sensible. In swifter Motions the Resistance alone is to be consider'd, which is as the Square of the Velocity.

18. When a Body is moved in any Liquid, the more blunt the Body is, by that means it is more retarded. If the Body be not immersed deep, the Resistance is to be distinguished from the Retardation.

19. When we speak of the same Body, the one may be taken for the other. From the Resistance arises a Motion contrary to the Motion of the Body; the Retardation is the Celerity, and the Resistance itself is the Quantity of Motion.

20. The Retardations of any Motions are, First, as the Squares of the Velocities: Secondly, as the Densities of the Liquids, through which the Bodies are moved: Thirdly, inversly, as the Diameters of those Bodies: Lastly, inversly, as the Densities of the Bodies themselves.

21. The Resistance of a Cylinder, which moves in the Direction of its Axis, is equal to the Weight of a Cylinder made of that Liquid, through which the Body is moved, having its Base equal to the Body's Base, and its Height equal to half the Height, from which a Body falling *in vacuo*, may require the Velocity with which the said Cylinder is moved through the Liquid.

22. When a Body, specifically heavier than a Liquid, is thrown up in it, a Body rises to a less Height than it would rise *in vacuo* with the same

ſame Celerity. But the Defects of the Height in a Liquid from the Heights to which a Body would riſe *in vacuo* with the ſame Celerities, are nearly as the Squares of the Heights *in vacuo*.

23. The Velocity of a Liquid, at any Depth, is the ſame as that which a Body, falling from a Height equal to that Depth, would acquire.

24. A Liquid riſes higher, if its Direction be a little inclined, than if it ſpouts vertically.

25. The Reſiſtance of the Air has a ſenſible Effect upon the Motions of Liquids; and in ſmall Heights, the Defects of the Heights from the Heights *in vacuo*; are in the Ratio of the Square of the Height of the Liquid above the Hole.

26. In the greateſt Heights of ſpouting Liquids, greater Holes are required. In all Heights there is a certain Meaſure of the Hole, through which the Liquid will riſe to the greateſt Height poſſible.

27. Liquids which ſpout obliquely, are not retarded from ſo many Cauſes, nor ſo much as thoſe that ſpout vertically.

28. A Liquid ſpouting from a Hole in the Centre, will go to the greateſt Diſtance poſſible.

29. The Squares of the Quantities flowing out, are in the Ratio of the Heights of the Liquids above the Holes.

30. If through equal Holes a Liquid runs out of a Cylinder, and out of another Veſſel of the ſame Height, (and in which the Liquid is always ſupplied, ſo as to be kept at the ſame Height,) in the time in which the Cylinder is emptied, there runs out twice as much Water from the other Veſſel as from the Cylinder.

31. Beſides the Irregularities from Friction, and the Reſiſtance of the Air, there are ſeveral others ariſing from the Coheſion of the Parts, even in Liquors that are not glutinous.

Flutings, by the *French* called *Cannelures*, are certain perpendicular Cavities cut length-ways around the Shaft of a Column, and rounded at the two Extremes. Their Number was at firſt limited to twenty-four in the *Ionic*, and twenty in the *Doric* Order; but that Limitation, ſome of our modern Architects have taken the liberty to diſpenſe with.

Flux *and* Reflux *of the Sea*. See *Tide*.

Fluxions, are the very ſmall, or rather indefinitely ſmall Particles of Quantities, being called by this Name by Sir *Iſaac Newton*, who conſiders them as the momentaneous Increments of Quantities. For Example: Of a Line by the Flux of a Point, and of a Superficies, by the Flux of a Line, and of a Solid by the Flux of a Superficies, and the Doctrine of theſe infinitely ſmall Parts, is likewiſe called *Fluxions*.

Fluxions are of vaſt uſe in the Inveſtigation of the Nature of Curves, and in the Diſcovery of the Quadratures of curvi-lin'd Spaces, and their Rectifications, and in performing many other admirable Effections, that can be done ſcarcely any other way.

The Fluxion of any generated Quantity is equal to the Fluxions of all the ſeveral generating Terms, multiplied into the Indexes of their Powers, and into their Co-Efficients continually.

If each Term of an Equation, whoſe Fluxion is required, be multiplied ſeparately by the ſeveral Indexes of the Powers of all the flowing Quantities contained in that Term, and in every ſuch Multiplication, if one Root or Letter of the Power be changed into its proper Fluxion, ſo ſhall the Aggregate of all the Products, connected together by

by their proper Signs, be the Fluxion of the Equation desired.

If the Fluxion of the Numerator of any Fraction be multiplied by the Denominator, and after it be placed with the Sign —, the Fluxion of the Denominator multiplied by the Numerator; then will this be the Numerator, and the Square of the Denominator will be the Denominator of the Fraction expressing the Fluxion of the given Fraction.

FLUXIONS (SECOND, THIRD, &c.) are the Fluxions of Fluxions, which are considered as flowing Quantities themselves: The second Fluxions being marked by two Points over them: Thus, $\ddot{y}$; the third by three; thus $\dddot{x}$; and so on.

If $\dot{x}$ be the Fluxion of the Quantity x, and $\frac{m}{n}$ be the Index of the Power of the same, and if for x be taken $x+\dot{x}$, and the Quantities $\overline{x+\dot{x}}|^{\frac{m}{n}}$, be expanded into a Series, we shall have $\overline{x+\dot{x}}|^{\frac{m}{n}} = x^{\frac{m}{n}} + \frac{m}{n}\dot{x}x^{\frac{m-n}{n}} + \frac{m^2-mn}{2n^2}\dot{x}\dot{x}x^{\frac{m-n}{n}} + \frac{m^2-3m^2n+2mn^2}{6n^3} \times \dot{x}\dot{x}\dot{x}x^{\frac{m-3n}{n}}$, &c. wherein the second Term $\frac{m}{n}\dot{x}x^{\frac{m-n}{n}}$ is the first Fluxion of $x^{\frac{m}{n}}$; the third Term $\frac{m^2-mn}{2n^2}\dot{x}\dot{x}x^{\frac{m-n}{n}}$ is the second Fluxion of $x^{\frac{m}{n}}$, and the fourth Term $\frac{m^2-3m^2n+2mn^2}{6n^3}\dot{x}\dot{x}\dot{x}x^{\frac{m-3n}{n}}$, the third Fluxion of $x^{\frac{m}{n}}$; and so on. This was discovered by Sir *Isaac Newton*, in the Year 1665.

FLY. See *Flie*.

FLYING PINION, is a Part of a Clock, having a Fly, or Fan, thereby to gather Air, and so to bridle the Rapidity of the Clock's Motion, when the Weight descends in the striking Part.

FOCUS *of an Ellipsis*, is a Point in the longest Axis on each side the Centre; from each of which if any two right Lines are drawn, meeting one another in the Periphery of the Ellipsis; their Sum will be always equal to the longest Axis; and so when an Ellipsis and its two Axes are given, and the Foci are required, you need only take half the longest Axis in your Compasses, and setting one Foot in the End of the shorter, the other Foot will cut the longer in the Focus required.

FOCUS *of an Hyperbola*, is a Point in the principal Axis within the opposite Hyperbola's; from whence, if any two right Lines are drawn meeting in either of the opposite Hyperbola's, their Difference will be equal to the principal Axis.

FOCUS *of a Parabola*, is a Point in the Axis within the Figure, distant from the Vertex one fourth Part of the *Latus Rectum*.

Here I cannot help taking notice of what is said by the Editors of the *Acta Eruditorum* at *Leipsic*, for *January* 1705, who, upon the coming out of Sir *Isaac Newton*'s Curves of the second Order, speak thus concerning them, in the Style of Mr. *Leibnitz*: (*Cæterum Autor non attingit Focos vel Umbilicos Curvarum secundi generis, & multo minus Generum altiorum. Cum ergo* ea

ea Res abstrusioris sit Indaginis, & maximi tamen in hoc genere Usus tum ad Descriptiones, tum ad alias Propertates Curvarum, & Doctrina hæc Focorum ab illustrissimo D. D. T. (Tschurnhaus) *profundius sit versata; Supplementum ejus pro his Curvis expectamus.* In *English* thus: 'But 'since the Author has not meddled 'with the Foci of the Curves of 'the second Order, and much less 'with those of the Curves of high-'er Orders: Therefore, as these 'are of a more abstruse Enquiry, 'and at the same time of the 'greatest Use, as well in the De-'scription, as the Discovery of o-'ther Properties of the Curves; and 'whereas the most illustrious 'D. D. T. (*Tschurnhaus*) is very 'deeply versed in the Doctrine of 'the Foci, we expect from him a 'Supplement to those Curves.'

Now, the Person who makes Observations upon this Passage of the Compilers of the *Leipsic* Acts (in the *Commercium Epistolicum*, published by Order of the Royal Society at *London*) and which, as I have been informed, was Sir *Isaac* himself, says, *Compilatores Actorum in scribendis Librorum breviariis a Censuris temerariis abstinere debent. Ex hac Censura patet Animus Scriptoris in D.* Newtonium. In *English*, 'The Compilers of the *Leipsic* Acts 'in their Abstracts of Books, should 'abstain from rash Censures; but 'here the opinion of the Writer, 'concerning Sir *Isaac Newton*, 'fully appears.' And this is very justly said; for it is well known, that the Curves of the second Order have no Foci. If by Foci are meant such Points that the Sum of any Number of right Lines drawn from them to any Point of one of these Curves shall be of a given Length, which one must suppose they mean, if they mean any thing by that Word, at least; if otherwise, their Meaning should have been explain'd.

Focus, in Optics, is the Point of Convergence, or Concurrence of the Rays of Light made by the Refraction, or the Reflection of a refracting or reflecting Substance.

1. In a Plano-Convex Glass, parallel Rays are united with the Axis, that is, the Focus is distant from the Pole of the Glass a Diameter of the Convexity, if the Segment be but thirty Degrees.

2. In double Convex-glasses of the same Sphere, the Focus is distant from the Pole of the Glass about the Radius of the Convexity, if the Segment be but thirty Degrees.

3. The Rays that fall nearer the Axis of any Glass, are not united with it so soon as those that are farther off; and the focal Distance in a Plano-Convex Glass will not be so great when the Convex-side is towards the Object, as on the contrary.

4. In viewing any Object or Body by a Plano-Convex Glass, the Convex-side must be turned outwards.

Focus Virtual. See *Virtual Focus*.

1. In Concave Glasses, when a Ray falls from Air parallel to the Axis, the Virtual Focus, by its first Refraction, is at the distance of a Diameter and a half of the Concavity.

2. In Plano-Concave Glasses, when the Rays fall parallel to the Axis, the Virtual Focus is distant from the Glass by the Diameter of the Concavity.

3. In Plano-Concave Glasses, as 107 : 193 :: so is the Radius of the Concavity to the Distance of the Virtual Focus.

4. In double Concaves of the same Sphere, parallel Rays have their Virtual Focus at the distance of the Radius of the Concavity.

5. But whether the Concavities be equal or unequal, the Virtual Focus, or Point of Divergency of the parallel

parallel Rays is determined by this Rule: As the Sum of the Radii of both Concavities : is to the Radius of either Concavity :: ſo is the double Radius of t'other Concavity : to the Diſtance of the Virtual Focus.

6. In Concave Glaſſes, if the Point to which the incident Ray converges, be diſtant from the Glaſs farther than the Virtual Focus of parallel Rays, the Rule for finding the Virtual Focus of this Ray, is this: As the Difference between the Diſtance of this Point from the Glaſs, and the Diſtance of the Virtual Focus from the Glaſs : is to the Diſtance of the Virtual Focus :: ſo is the Diſtance of this Point of Convergence from the Glaſs : to the Diſtance of the Virtual Focus of this converging Ray.

7. In Concave Glaſſes, if the Point to which the incident Ray converges be nigher to the Glaſs than the Virtual Focus of parallel Rays, the Rule to find where it croſſes the Axis, is this : As the Exceſs of the Virtual Focus more than this Point of Convergency from the Glaſs : is to the Virtual Focus :: ſo is the Diſtance of this Point of Convergency from the Glaſs : to the Diſtance of the Point where this Ray croſſes the Axis.

To find the Focus of a Meniſcus Glaſs; ſee under the Word *Meniſcus.*

If there be a Burning-Glaſs of a Foot in Diameter, this will conſtipate or croud together all the Rays of the Sun which fell before on the Area of a Circle twelve Inches in Diameter, into the Compaſs of one eighth Part of an Inch, the Area's then of the two Circles will be as 9216 to 1; and conſequently the Heat of the leſſer to the Heat of the greater, will be reciprocally as 9216 to 1 : that is, the Heat in the Focus will exceed the Sun's common Heat at that time 9216 times; and this will have an effect as great as the direct Rays of the Sun would have on a Body placed at one ninety-ſixth Part of the Diſtance of the Earth from the Sun, or on a Planet that ſhould move round the Sun at but a very little more than a Diameter of the Sun's Diſtance from him, or that would never appear farther from him than about thirty-ſix Minutes.

Dr. *Halley*, in the *Philoſophical Tranſactions*, N° 205. ſhews a general way of finding the Foci of ſpherical Glaſſes by Computation. So does Mr. *Ditton*, in his *Fluxions.* See alſo Dr. *Gregory*'s *Elements of Dioptrics.*——Mr. *Carré* and *Guiſnée* in the *Memoires de l'Acad. Royale des Sciences.* And beſides theſe, ſeveral others who have wrote upon this Subject: Amongſt which, Dr. *Barrow*'s and Sir *Iſaac Newton*'s Ways of finding geometrically the Foci of ſpherical Glaſſes, (to be ſeen in Dr. *Barrow*'s *Optical Lectures*) appear to me to be far more neat and elegant than any I have elſewhere ſeen.

Foliate, a Name given by ſome (as the ingenious Mr. *De Moivre* in the *Phil. Tranſact.*) to a Curve Line of the ſecond Order, expreſſed by the Equation $x^3 + y^3 = axy$, being one Species of defective Hyperbola's, with one Aſymptote, and conſiſting of two infinite Legs croſſing one another, and forming a ſort of Leaf. (See *Species* 42. of Sir *Iſaac Newton*'s Lines of the third Order.)

Fomahant, a Star of the firſt Magnitude in *Aquarius*, whoſe Longitude is 329 deg. 17 min. Latitude 21 deg. 3 min.

Foot-Brank, or Banquette, in Fortification, is a ſmall Step of Earth, on which the Soldiers ſtand to fire over the Parapet.

Fore-Staff. See *Croſs-Staff.*

Fort-

Fort, is a Castle or Place of small Extent, fortified either by Art or Nature.

Fort-Royal, is that which hath twenty-six Fathoms for the Line of Defence.

Fort-Star, is a Redoubt, constituted by re-entring and saliant Angles, which commonly have from five to eight Points. See more under the Word *Sconces*.

Fortification, or Military Architecture, is the Art shewing how to fortify a Place with Ramparts, Parapets, Moats, and other Bulwarks; to the end, that a small Number of Men within, may be able to defend themselves for a considerable time against the Assaults of a numerous Army without; so that the Enemy, in attacking them, must of necessity suffer great Loss.

Fortification is either regular, or irregular, and with respect to time, may be distinguished into durable and temporary.

Fortification (Durable,) is that which is raised to continue a long while.

Fortification (Irregular,) is that where the Sides and Angles are not all uniform, equidistant, nor equal one to another.

Fortification (Regular,) is that which is built on a regular Polygon, the Sides and Angles whereof are all equal; being commonly about a Musket-shot one from another.

Fortification (Temporary,) is that which is erected upon an emergent occasion for a little time. Such are all sorts of Works cast up for the seizing or maintaining of a Post or Passage; as also Circumvallations, Contravallations, Redoubts, Trenches, Batteries, &c.

1. Every Place within the Fortification ought to be flanked, that is, seen side-ways, or defensible from the other Parts; so that there may be no Place in which an Enemy can lodge himself undiscovered by those that are within, and that both from the Front, the Sides, even from behind, if possible.

2. The Fortress ought to command all Places round about, and therefore all the Out-Works must be lower than the Body of the Place.

3. The Works that are most remote from the Centre of the Place, ought always to be open to those that are more near.

4. The Angle-Flanquant, or the Point of the Bastion, ought to be, at least, of seventy Degrees, or as some say, (Mr. *Vauban*,) not more than a hundred, or less than sixty.

5. The Angle of the Courtin ought never to be less than ninety, or greater than a hundred Degrees; because if it be larger, 'tis too much subject to the View of the Enemy.

6. The greater the Flank and Demigorge is, in proportion to other Things, the better, because there is both more room to retrench in, and also because there may be made retiring Flanks, which add very much to the Strength of a Place.

7. The Line of Defence ought never to exceed point-blank Musket-shot, which is about an hundred and twenty, or a hundred and twenty-five Fathoms.

8. The Bastions that are not too little, nor yet too excessively big, are to be preferred before others; and the Angle of a Bastion should not exceed a hundred, nor be less than sixty Degrees.

9. The greater the Angle that is made by the outward Polygon and the Face shall be, the greater is the Defence of the Face.

10. Whatsoever incloses a durable Fortification, must be either Flank, Face, or Courtin, built so well, that the first Discharge of the

Cannon may not be able to pierce through it.

11. 'Tis impossible to fortify a Triangle after the common way, because the Angle of the Gorge is always less than ninety Degrees.

12. The acuter the Angle at the Centre is, the Place is by so much the stronger, because it will have the more Sides.

13. In a regular Fortification the Face must never be less than half the Courtin; and the Faces of the Bastion ought to be defended by the small Shot of the opposite Flank.

14. Any Trenches are preferable to those filled with Water, especially in great Places, where Sallies, Retreats, and Succours are frequently necessary; but in small Fortresses, Water-Trenches that cannot be drained are best, because there is no need of Sallies, Succours, *&c.*

There are many Writings upon Fortification: Some of which are *Melder*'s *Praxis Fortificatoria.*— *Les Fortifications de Compte de Pagan.*— *L'Ingenieur parfait du Sieur de Ville.* — *Sturmy*'s *Architectura Militaris Hypothetica.*—*Blondel*'s *Nouvelle Maniere de Fortifier les Places.*— The *Abbé de Fay*'s *Veritable Maniere de bien Fortifier de M. Vauban.*— *L'Ingenieur François.*—*Coborn*'s *Nouvelle Fortification tant pour un terrain bas & humide, que sec & elevé.*—— *Alexander de Grotte*'s & *Donatus Roselli*'s *Fortification.*—— *Medrano*'s *Ingenieur Francoise.*—The Chevalier *de Saint Julien*'s *Architecture Militaire.*—— *Landsberg*'s *Nouvelle Maniere de Fortifier les Places.*—— An anonymous Treatise in *French*, called *Nouvelle Maniere de Fortifier les Places, tirée des Methodes du Chevalier de Ville*, &c.— *Ozanam*'s *Traité de Fortification.*— *Memoires de l'Artillerie de Surirey de St. Remy.*

Fortines, or Field-Forts, are Sconces, or little Fortresses, whose flanked Angles are generally distant one from another 120 Fathom; but their Extent and Figure are different, according to the Situation or Nature of the Ground, some of them having whole Bastions, and others only Demi-Bastions. They are made use of only for a time, either to defend the Lines of Circumvallation, or to guard some Passage, or dangerous Post.

Fraction, is a broken Number, signifying one or more Parts, proportionally of any Thing divided: It consists of two Numbers set one over another, with a Line between them, as $\frac{5}{8}$. In all Fractions, as the Numerator : is to the Denominator :: so is the Fraction itself : to that whole of which it is a Fraction. Hence there may be infinite Fractions of the same Value one with another; for there may be infinite Numbers found, which shall have the same Proportion one to another.

1. When the Numerator is less than the Denominator, the Fraction is less than the whole, and consequently is what they call a proper Fraction.

2. But when the Numerator is either equal to, or greater than the Denominator, the Fraction is called *improper*, because 'tis equal to, or greater than the whole. Thus $\frac{4}{4}$ is equal to 1, and $\frac{5}{4}$ is equal to 1, and $\frac{1}{4}$.

3. Fractions are single or compound.

4. Single Fractions are such as have but one Numerator, and one Denominator, as $\frac{3}{4}$, $\frac{5}{4}$, $\frac{11}{12}$.

5. Compound Fractions, or Fractions of Fractions, are such as consist of more than one Numerator, and one Denominator, as $\frac{1}{2}$ of $\frac{3}{4}$ of $\frac{5}{6}$, and are always connected by the Word *of*.

6. All Fractions, whose Numerators and Denominators are proportional, are equal to one another. As the Fractions $\frac{2}{3}$, $\frac{20}{30}$, $\frac{14}{21}$, are all equal.

Every

Every Fraction, such as $\frac{1}{e+fz+gz^2+hz^3}$, &c. may be reduced into as many single ones, as there are Roots in its Denominator.

FRAISES, in Fortification, are pointed Stakes fixed in Bulwarks made of Earth, on the one side of the Rampart, a little below the Parapet. These Stakes, being from seven to eight foot long, are driven in almost half way into the Earth, and present their Points somewhat sloping toward the Field. They serve to prevent Scalades and Desertion.

FRAME, is the Out-Work of a Clock or Watch, consisting of the Plates and Pillars, and which contains in it the Wheels, and the rest of the Work.

FREESE, a Term in Architecture. See *Freeze*.

FREEZE, a large Flat-Member, which separates the Architrave from the Cornice. The Word comes from *Latin*, *Phrygio*, an Embroiderer; the Freezes being frequently adorned with Figures in Bass-Relief, somewhat in imitation of Embroidery. The Freeze is sometimes also expressed by the Word *Zophoros*, from the *Greek*, *Zoophoros*; it being usual for Animals to be represented upon it.

FRESCO, in Architecture, is a Sort of Painting, which is made upon the Plaistring of an Edifice before it be dry.

FRICTION, is the Resistance arising from the Motion of one Superficies upon another, and is caused by their Defect of Slipperiness.

Mr. *Romer* and *De la Hire* have shewn in the *French Memoirs*, that the Figures of the Teeth of Wheels ought to be Epicycloids, that so their Resistance may be the least possible. And it is a great deal of pity that this has not hitherto been put in practice.

FRIGID ZONES. See *Zones*.

FRONT, in Perspective, is the Orthographical Projection of an Object upon a parallel Plane.

FRONT, in Fortification, is what the *French* call *Tenaille de Place*, and the *Face of a Place*. It is that which is comprehended between the Points of any two neighbouring Bastions, *viz*. the *Courtin*, and two Flanks, which are raised upon the *Courtin*, and the two Faces of the Bastion, which look towards one another.

FRONT-LINE, in Perspective. See *Line of the Front*.

FRONTISPIECE. See *Portale*.

FRONTON, is a Part or Member in Architecture, which serves to compose an Ornament raised over Doors, Cross-Works, Niches, &c. sometimes making Triangles, and sometimes Parts of a Circle. It is also called *Fastigium* by *Vitruvius*, and *Pedisment* by the *French*.

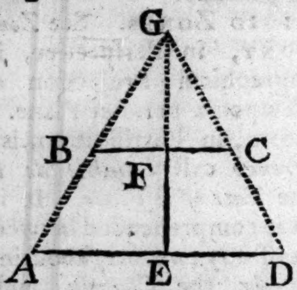
FROZEN ZONES. See *Zones*.

FRUSTUM, in Geometry, signifies a Piece cut off, or separated from any Body; as the Frustum of a Pyramid or Cone, is a Part or Piece of them cut off (usually) by a Plane parallel to the Base.

The Solidity of the Frustum of a Pyramid with a square Base will be had, by adding the Area's of the upper and under Bases to a mean Proportional between them, and multiplying that Sum by one Third Part of the Height of the Frustum; and as 14 to 11 nearly, so is the Solidity of the Frustum of a square Pyramid, to the Solidity of the Frustum of a Cone, whose Diameters at Top and Bottom, are equal to the Sides of the upper and lower Base, and Height equal.

The following Demonstration of the Theorem above, being not to be

found every where, may not be displeasing to some. Let AD the Base



of the Frustum ABCD of a square Pyramid be called a, the upper Base BC, b; the Height EF, c; the Height EG of the whole Pyramid y; and the Height FG of the Pyramid BGC, x; then $a : y :: b : x$. and $a^3 : aay :: b : x$; also $a : y :: b^3 : bbx$; therefore $a^3 : aay :: b^3 : bbx$; and $a^3 : b^3 :: aay : bbx$; and (dividendo) $a^3 - b^3 : aay - bbc :: a^3 : aay$; and so $a^3 - b^3 : aay - bbc :: a : y$; that is, as $a - b : c$; that is, $\overline{a-b} \times \overline{aa+bb+ab} : aay - bbx :: a - b : c$; that is, $\overline{a-b} \times \overline{aa+bb+ab} : aay - bbx :: cc \times \overline{a-b} : c^3$; and $\overline{a-b} \times \overline{aa+bb+ab} : cc \times \overline{a-b} :: aay - bbx : c^3$; that is, $aa+bb+ab : cc :: aay - bbx : c^3$; that is, $c \times \overline{aa+bb+ab} . c^3 :: aay - bbc : c^3$; wherefore $c \times \overline{aa+bb+ab} = aay - bbx$; and $\frac{1}{3}$ of the one will be equal to $\frac{1}{3}$ of the other. But $\frac{1}{3}$ of $aay - bbx$ is equal to the Frustum; therefore $\frac{1}{3}$ of $c \times \overline{aa+bb+ab}$ will be equal to the Frustum.

This may be demonstrated otherwise, by supposing the Frustum of the Pyramid to consist of one right-angled Parallelipipedon, whose Altitude is EF, and Side of the square Base BC: of four Pyramids; the Sides of each of whose square Bases is $\frac{AD-BC}{2}$, and Altitude EF; and of four equal triangular Prisms, whose common Altitude is BC, and Bases equal right-angled Triangles, each equal to $\frac{1}{2} \times \frac{AD-BC}{2} \times EF$.

Fugue, in Musick, is some Part consisting of four, five, six, or any Number of Notes begun by some one single Part, and then seconded by a third, fourth, fifth, and sixth Part; if the Composition consists of so many, repeating the same, or such-like Notes; so that several Parts follow, or come in one after another in the same manner, the leading Parts still flying before those that follow.

Fugue-Double, is when two or more different Parts move together in a Fugue, and are alternately interchanged by several Parts.

Fuliginous Vapours, by some, are thick, impure, and sooty Vapours.

Furniture *of a Dial*, are such Lines as are drawn thereon for Ornament; as the Parallels of Declination, Length of the Day, Azimuths, Points of the Compass, *Babylonish* and *Jewish* Hours, *&c.*

Fusarole, is a small round Member in Architecture, cut in form of a Collar, with somewhat long Beads, under the Echinus, or Quarter-Round of Pillars of the *Dorick*, *Ionick*, and *Composite* Orders.

Fuse, or Fusil, *of a Bomb or Granado-Shell*, is that which makes the whole Powder, or Composition in the Shell, take fire, to do the designed Execution. 'Tis usually a wooden Pipe or Tube filled with Wild-Fire, or some such Composition, and is designed to burn so long, and no longer, as is the Time of the Motion of the Bomb from the Mouth of the Mortar to the Place where it is to fall, which Time Mr. *Anderson* makes to be about 27 Seconds; so that the Fuse must be contrived either from the Nature of the

the Wild-Fire, or the Length of the Pipe which contains it, to burn just that time.

Fust, in Architecture, signifies the Trunk or Shaft of a Column, being that Part comprehended between the Base and the Capital. *Vitruvius* calls it *Scapus*.

Fusy, is that Part of a Watch about which the Chain or String is wrapped, and is that which the Spring draweth, being in form commonly taper. In larger Works, going with Weights, it is cylindrical, and is called the *Barrel*.

G.

GABIONS, a Term in Fortification, signifying Baskets made of Osier-Twigs, equally wide at the top and bottom, about four Foot in Diameter, and from five to six high; which being filled with Earth, are sometimes used as Merlons for the Batteries, and sometimes as a Parapet for the Lines of Approach, when it is requisite to carry on the Attacks through a stony or rocky Ground, and to advance them with extraordinary Vigour. They serve also to make Lodgments in some Posts, and to secure other Places from the Shot of the Enemies, who nevertheless endeavour to set the Gabions on fire with pitched Faggots, to render them useless.

Gable-End *of a House*, is the upright Triangular-End from the Cornice, or Eaves, to the top of its Roof.

Gage-Point. See *Gauge-Point*.

Gallery, in Fortification, is a cover'd Walk, the Sides whereof are Musket-Proof, consisting of a double Row of Planks lined with Plates of Iron; the top being sometimes covered with Earth or Turf, to hinder the Effect of the artificial Fire of the Besieged. These Galleries are frequently made use of in the Moat, already filled with Faggots and Bavins, to the end that the Miner may approach safe to the Face of the Bastion, when the Artillery of the opposite Flank is dismounted.

Gardecaut, or Gard-du-Cord, is that which stops the Fusy of a Watch, when wound up, and for that end is driven up by the String. Some call it *Guard-Cock*, others *Guard-du-Gut*.

Gauge-Point *of a solid Measure*, is the Diameter of a Circle, whose Area is equal to the solid Content of the same Measure; as the Solidity of a Wine-Gallon being 231 Cubic Inches, (according to *Winchester* Measure;) if you conceive a Circle to contain so many Inches, the Diameter of it will be 17.15; and that will be the Gauge-Point of Wine Measure: and an Ale-Gallon containing 288 Cubic Inches, by the same Rule; the Gauge-Point for Ale-Measure will be 19.15.

Gauging, is finding the Capacities or Contents of all Sorts of Vessels which hold Liquids, Powders, Meal, Corn, &c.

The common Rule for finding the Contents of all Ale and Wine Casks, is to take the Diameters at the Bung, and at the Head; by which you may find the Areas of the Circle there; then you must take two thirds of the Area of the Circle at the Bung, and one-third of the Area of the Circle at the Head, and add them together into one Sum, which Sum multiply'd by the internal Length of the Cask, gives the Content in solid Inches, which you may turn into Gallons, by dividing by 282 for Ale, and 231 for Wine Gallons.

The Writers upon Gauging are, *Hunt*, *Everard*, *Douharty*, *Shettleworth*, &c.

Gauging-Rod. This Rod, whose Use is to find the Quantities of Liquors contained in any kind of Vessels, is usually made of Box-Wood, and consists of four Rules, each a Foot long, and about three Eighths of an Inch square, joined together by three Brass Joints; by which means the Rod is render'd four Foot long; when the four Rules are quite open'd, and about one Foot when they are folded together.

1. On the first Face of this Rod are placed two Diagonal Lines, one for Beer, and the other for Wine; by means of which, the Content of any common Vessel in Beer or Wine-Gallons may be readily found, in putting the Rod in at the Bung-Hole of the Vessel, until it meets the Intersection of the Head of the Vessel, with the opposite Staves to the Bung-hole.

2. On the second Face of this Rod are a Line of Inches, and the Gauge-Line, which is a Line expressing the Areas of Circles, whose Diameters are the correspondent Inches in Ale-Gallons.

3. On the third Face are three Scales of Lines. The first is for finding how many Gallons there is in a Hogshead, when it is not full, lying with its Axis parallel to the Horizon. The second Line is for the same Use as that for the Hogshead. The third Line is to find how much Liquor is wanting to fill up a Butt when it is standing.

4. Half way the fourth Face of the Gauging-Rod are three Scales of Lines, to find the Liquors wanting in a Firkin, Kilderkin, and Barrel, lying with their Axes parallel to the Horizon.

Gazons, in Fortification, are Pieces of fresh Earth cover'd with Grass, cut in form of a Wedge, about a Foot long, and half a Foot thick, to line Parapets, and the Transverses of Galleries.

Gemini, one of the twelve Signs of the Zodiac, being the third in order; also a Constellation of that Name.

Generating Line, or Figure, in Geometry, is that which by its Motion or Revolution produces any other Plane or Solid Figure. Thus a Right Line moved any way parallel to itself, generates a Parallelogram; round a Point in the same Plane, with one End fasten'd in that Point, it generates a Circle; one entire Revolution of a Circle in the same Plane, generates the Cycloid; the Revolution of a Semicircle round its Diameter, generates a Sphere, &c. Sir *Isaac Newton* uses the word.

Generated, or Genited Quantity, in a very large Sense, is taken for whatever is produced either in Arithmetic, by Multiplication, Division, or Extraction of Roots; or in Geometry, by the Invention of the Contents, Areas, and Sides of Figures.

Genesis, in Geometry, is the Formation of any Plane or Solid Figure by the Motion of some Line or Surface, which Line or Surface is always called the *Describent*; and that Line, according to which the Motion is made, is called the *Dirigent*.

Geocentric, signifies any Planet or Orb that has the Earth for its Centre, or the same Centre with the Earth.

Geocentric Latitude *of a Planet*, is the Angle, which a Line joining the Planet and the Earth, makes with the Line drawn perpendicular to the Plane of the Ecliptic.

Geocentric Place *of a Planet*, is a Point of the Ecliptic, to which the Planet seen from the Earth is referred.

Geodæsia, Surveying, or the Art of measuring Land.

Geodetical Numbers, are ſuch as are conſidered according to thoſe vulgar Names or Denominations, by which Money, Weights, Meaſures, &c. are generally known, or particularly divided by the Laws and Cuſtoms of ſeveral Nations.

Geographical Mile, is the Sea-Mile, or Minute, being one ſixtieth Part of a Degree of a great Circle on the Earth's Surface.

Geography, is the Science that teaches and explains the Properties of the Earth, and the Parts thereof that depend upon Quantity.

Some of the Geographical Writers amongſt the Ancients were *Ptolemy*, *Pliny*, *Strabo*, and *John de Sacroboſco*. Amongſt the Moderns we have *Cluverius*, *Heylin*, *Ricciolus*, *Varenius*, *Morden*, *Bohoun*, *Echard*, *Gordon*, &c.

Geometrical, or Algebraic Curves, are thoſe whoſe Ordinates and Abſciſſes being right Lines, the Nature thereof can be expreſſed by a finite Equation, having thoſe Ordinates and Abſciſſes in it.

Geometrical Lines or Curves are divided into Orders, according to the Number of Dimenſions of the Equation, expreſſing the Relation between the Ordinates and Abſciſſa's, or according to the Number of Points, by which they may be cut by a right Line. So that a Line of the firſt Order will be only a right Line expreſſed by the Equation $y+ax+b=0$. A Line of the ſecond or quadratic Order, will be the Conic Sections, and Circle, whoſe moſt general Equation is $y^2+\overline{ax+b}\,xy+cx^2+dx+e=0$. A Line of the third Order, is that whoſe Equation has three Dimenſions, or may be cut by a right Line in three Points, whoſe moſt general Equation is $y^3+\overline{ax+b}\times y^2+\overline{cx^2+dx+e}\times y+fx^3+gx^2+hx+k=0$. A Line of the fourth Order, is that whoſe Equation has four Dimenſions, or which may be cut in four Points by a right Line whoſe moſt general Equation is $y^4+\overline{ax+b}\times y^3+\overline{cx^2+dx+e}\times y^2+\overline{fx^3+gx^2+hx+k}\times y+lx^4+mx^3+nx^2+px+q=0$. And ſo on *ad infinitum*.

And a Curve of the firſt kind (for a right Line is not to be reckon'd amongſt Curves) is the ſame with a Line of the ſecond Order; and a Curve of the ſecond Order the ſame as a Line of the third; and a Line of an infinite Order is that which a right Line can cut in an infinite Number of Points, ſuch as a Spiral, Quadratrix, Cycloid, the Figures of the Sines, Tangents, Secants, and every Line which is generated by the infinite Revolutions of a Circle or Wheel.

In each of the ſaid Equations x is the Abſciſs, and y a correſpondent Ordinate, making any given Angle with it; a, b, c, d, &c. given Quantities, affected with their Signs + and —, whereof one or more may be wanting, provided by ſuch Defect the Line does not become one of an inferior Order.

1. The moſt complicated or general Equation of geometrical Lines of all Orders is $y^n+\overline{ax+b}\times y^{n-1}+\overline{cx^2+dx+e}\times y^{n-2}+\overline{gx^3+hx^2+kx+l}\times y^{n-3}+$ &c. $+mx^n+rx^{n-1}+sx^{n-2}+px^{n-3}+$ &c. $+q=0$. where n expreſſes the Order of the Line, and $a, b, c, d, e, g, h, k, l$, &c. m, r, s, p, &c. q conſtant Quantities, variouſly affected with the Signs + and —, the Number of the Terms being the Sum of the natural Numbers decreaſing from $n+1$ to 0, and the Number of the Co-efficients or

or invariable Quantities will be $\frac{n^2+3n}{2}$.

2. The general Equation $y^2 + \overline{ax+b} \times y + cx^2 + dx + e = 0$ of all Curves of the first kind may be transmuted into a more simple one, still expressing them all, *viz.* $z^2 = fx^2 + gx + h$, where z is the Ordinate, x the Abscis, and f, g, h, constant Quantities. For by extracting the Root, y will be $= \frac{ax+b}{2} \pm \frac{1}{2}\sqrt{4cx^2 + a^2x^2 + 2abx + 4dx + bb + 4e}$; that is, supposing $p = 4c + a^2$, $q = 2ab + 4d$, and $r = bb + 4e$, it will be $y = \frac{ax+b}{2} \pm \frac{1}{2}\sqrt{px^2 + qx + r}$; and if again we suppose $z = y \pm \frac{ax+b}{2}$, $f = \frac{p}{4}$, $g = \frac{q}{4}$, and $h = \frac{r}{4}$, we shall have $z = \sqrt{fx^2 + gx + h}$, and so $z^2 = fx^2 + gx + h$.

Hence when the Term fx^2 is affirmative, the Curve expressed by the Equation $z^2 = fx^2 + gx + h$ will be an Hyperbola. When the same is negative, an Ellipsis; and when the same is absent, a Parabola; so that there are but three different Species of Curves of the first kind.

When the Root of the Quantity in the Vinculum being Part of the Value of y can be extracted, the Locus of the given Equation will be a right Line.—When the Terms y^2 and cx^2 are wanting, the Curve expressed by the Equation above will be an Hyperbola, when the Abscis is either an Asymptote, or parallel to it, and the Ordinates are parallel to the other Asymptote.

3. If the Ordinate of a Curve be parallel to a Tangent at a Point infinitely distant, that Ordinate in the Equation defining the Curve, will not ascend to so many Dimensions as the Curve; so that $x = a$ expresses a right Line where the Ordinate y is of no Dimension. $\overline{x+a} \times y = bx^2 + cx + d$, expresses all Lines of the second Order which run on *ad infinitum*. $\overline{x+a} \times yy = \overline{bx^2+cx+d} \times y + \overline{ex^3+fx^2+gx+h}$ all Lines of the third Order that runs out to Infinity, and generally $\overline{x+a} \times y^n = \overline{bx^n + cx^{n-1} + dx^{n-2}, \&c.} \times y^{n-1} + \overline{ex^{n-1} + fx^{n-2} + gx^{n-3}, \&c.} \times y^{n-2}$, &c. $+ hx^n + kx^{n-1} + lx^{n-2}$, &c. $+ q$, expresses all Curves that run out infinitely.

4. The general Equation of all Curves of the second kind may be transmuted to the four following particular Equations still expressing them all, *viz.* $xy^2 - ey = ax^3 + bx^2 + cx + d$. $xy = ax^3 + bx^2 + cx + d$. $yy = ax^3 + bx^2 + cx + d$. and $y = ax^3 + bx^2 + cx + d$. The first of which Equations represents a Figure, having six hyperbolical Legs with three Asymptotes, forming an Isosceles Triangle, if the Term ax^3 be affirmative. But if the Term ey be absent, the three Asymptotes meet in a Point, in the Abscis; and of these Curves, which Sir *Isaac Newton* calls redundant Hyperbola's, there are nine different Species without Diameters; twelve with but one Diameter; two with three Diameters; nine with three Asymptotes, converging to a common Point. But when ax^3 is negative, the Figure expressed by that Equation will be a defective Hyperbola; of which there are six different Species, having but one Asymptote, and only two hyperbolical Legs, running out contrary ways *ad infinitum*. the

Asymptote

Aſymptote being the firſt and principal Ordinate; and when the Term ey is not abſent, the Figure will have no Diameter; but if abſent, it will have one Diameter. And of theſe latter, there are ſeven different Species.— If the Term ax^3 be abſent, but bx^2 not, the Figure expreſſed by the Equation remaining will be a parabolical Hyperbola, having two hyperbolical Legs to one Aſymptote, and two parabolical Legs converging one and the ſame way. And when the Term ey is abſent, the Figure will have but one Diameter; but when not, it will have no Diameter. And of this latter there are four different Species, according to Sir *Iſaac Newton*.

In the firſt Caſe of the Equation, when the Terms ax^3, bx^2, are wanting, that is, when the Equation becomes $xy^2 + ey = cx + d$, it expreſſes a Figure conſiſting of three Hyperbola's oppoſite to one another, one lying between the parallel Aſymptotes, and the other two without, having three Aſymptotes, one of which is the firſt and principal Ordinate, and the other two are parallel to the Abſciſs, and equally diſtant from it; or elſe two oppoſite Hyperbola's without the Aſymptotes, and a Serpentine Hyperbola between them; there being four different Species of theſe Curves called by Sir *Iſaac Newton*, the *Hyperboliſmæ* of an *Hyperbola*.

When the Term cx^2 is negative, the Figure expreſſed by the Equation $xy^2 + ey = -cx^2 + d$, is a Serpentine Hyperbola, having only one Aſymptote, being the principal Ordinate, or elſe a conchoidal Figure; there being three different Species of theſe Curves, called by Sir *Iſaac Newton* the *Hyperboliſmæ of an Ellipſis*.

When the Term cx^2 is abſent, the Equation $ey^2 + ey = d$ expreſſes two Hyperbolas, not lying in the oppoſite Angles of the Aſymptotes, but in the adjacent Angles; there being two different Species of theſe Curves, called by Sir *Iſaac Newton*, the *Hyperboliſmæ of a Parabola*.

The ſecond Caſe of Equations, *viz.* $xy = ax^3 + bx^2 + cx + d$, expreſſes a Figure having two hyperbolical Legs to one Aſymptote, being the principal Ordinate, and two parabolical Legs.

The third Caſe of Equations $yy = ax^3 + bx^2 + cx + d$, expreſſes a Figure having two parabolical Legs running out contrary ways; and of theſe there are five different Species. Sir *Iſaac Newton* calls them *Diverging* or *Bell-form Parabola's*. See more concerning them under the Word *Parabola Diverging*.

The fourth Caſe of Equations $y = ax^3 + bx^2 + cx + d$, expreſſes a Parabola with contrary Legs, *viz.* the Cubical Parabola.

4. Thus, according to Sir *Iſaac Newton*, there are but 72 Species of Lines of the third Order. But Mr. *Sterling* afterwards found out four more Species of redundant Hyperbola's; and I myſelf two more of the deficient Hyperbolas expreſſed by the Equation $xyy = bx^2 + cx + d$. When $bx^2 + cx + d = 0$ has two unequal negative Roots, and two equal negative Roots; ſo that in reality there are 78 different Species of Lines of the third Order.

5. How the ſeveral Equations for all Lines of the third Order when the Ordinates are parallel to an Aſymptote, may be tranſmuted into the four particular Equations above mentioned, is elegantly enough ſhewn by Mr. *Sterling* in his *Illuſtratio Tractatus* D. Newtoni *de Enumeratione Linearum tertii Ordinis*. The ſame is done by Mr. *Nichol* too, in the *Memoires de l'Academie Royale de Sciences*, *Anno* 1728. but triflingly long and tedious. Altho' I have ſaid that the Lines of the

third Order consist either of hyperbolical or parabolical Parts, yet some of them have besides, Ovals belonging to them, either separate from the infinite Legs, or joining to them; they have also double Points, which make a part of the Curve, and other notable Distinctions, as may be seen in Sir *Isaac Newton*'s Enumeration of these Lines, where you have their Figures as well as the Qualifications of the several Equations expressing each different Species, chiefly arising from the Equation, expressing the Value of the Ordinate y in the Terms of the Abscis x; giving no Ordinate, as often as that Value is the Square Root of a negative Quantity, or Part of that Value; an infinitely small Ordinate; a finite one; or an infinitely great one: for Example, in the first Case of Equations $xy^2 - ey = ax^3 + bx^2 + cx + d$, it will be found by extracting the Root that $y = \frac{e}{2x} \pm$

$$\sqrt{\frac{ax^4 + bx^3 + cx^2 + dx + \frac{1}{4}ee}{x}};$$

so that y will be possible as often as $ax^4 + bx^3 + cx^2 + dx + \frac{1}{4}ee$ is affirmative, and impossible when the same is negative: And the Number of Times that this can happen will appear from the Description of a biquadratical Parabola, whose Abscis is x, and Ordinate $ax^4 + bx^3 + cx^2 + dx + \frac{1}{4}ee$.

Mr. *Sterling* in the Treatise aforesaid has shewn how to find the Figures and several Species of these Curves by throwing the Value of the Ordinate y into an infinite Series, which certainly is a very short and general way of doing the thing; but at the same time is both difficult, unnatural, and obscure; and more especially to such who are not well versed in the Doctrine of Series's. And this, no doubt, made Mr. *Nichol*, in the *Memoires* above related, give a Specimen of performing the Business by finite Equations; and since him, I myself have wrote a little Treatise, shewing almost by Inspection not only how the several Species of those Curves arise from the previous Description of other Curves (whose Abscis is x, and Ordinate the whole Value of y, or Part of that Value) but also the manner of finding any Number of Points through which they must pass, and that after a way the most simple and natural the thing seems to admit.

6. Sir *Isaac Newton* tells us, that Curves may be generated by Shadows. He says, if upon an infinite Plane illuminated from a lucid Point the Shadows of Figures be projected; the Shadows of the Conic Sections will be always Conic Sections; those of the Curves of the second kind will be always Curves of the second kind; those of the Curves of the third kind will be always Curves of the third kind; and so on *ad infinitum*.

And like as a Circle by projecting its Shadow generates all the Conic Sections, so the five diverging Parabola's by their Shadows will generate, and exhibit all the rest of the Curves of the second kind: and so some of the most simple Curves of the other kinds may be found, which will form, by their Shadows upon a Plane, projected from a lucid Point, all the rest of the Curves of that same kind. But as Sir *Isaac Newton* has neither demonstrated what he here says, nor has particularly shewn how his Curves of the second Order may be derived from the Shadows of the diverging Parabola's, you have in the *French Memoires* a Demonstration of this, and a Specimen of a few of the Curves of the second Order, which may be generated

generated by a Plane's cutting a Cone or Solid formed from the Motion of an infinite right Line along a diverging Parabola (having an Oval) always paſſing thro' a given or fixed Point above the Plane of that Parabola.

Mr. *Mac-Laurin*, in his *Organica Geometria*, ſhews how to deſcribe ſeveral of the Species of Curves of the ſecond Order, eſpecially thoſe having a double Point, by the Motion of right Lines and Angles; but a good commodious Deſcription by a continued Motion of thoſe Curves which have no double Point is (by Sir *Iſaac Newton*) ranked amongſt the moſt difficult Problems.

As nobody before Sir *Iſaac Newton* ever did, or I believe could, give the Figures, various Species, and principal Properties of the Curves above the Conic Sections, (altho' in the Preface to *De Witts*'s *Elementa Linearum Curvarum*, a Treatiſe upon the Curves of the ſecond Order was promiſed); ſo it is my firm belief, that no one after him will be able to enumerate the ſeveral different Species, and exhibit the Figures of the Curves of the third Order, of which I imagine there are ſome thouſands, not ſo much by reaſon of the Difficulty of the thing, as the want of Inclination to purſue it. Four or five Years ago I was very fond of this Buſineſs, and have now by me ſome hundreds of the Curves of the third Order; but finding the Number behind ſtill very great, my Inclination began to abate, till at length I grew quite tired of the Work, and laid it aſide. The *Abbé Bragelonge* in the *French Memoires* of the *Royal Academy*, has given a Diſcourſe upon ſome of the Curves of this Order, which is both long and tedious, and very far ſhort of a compleat Treatiſe on this Subject; and at the End he promiſes an Enumeration of the ſeveral Species of theſe Curves. But ſince I have not yet ſeen any ſuch thing, he may perhaps have fallen into my Condition.

The General Equation of all Curves of the third kind may be reduced to the following ten particular Equations, which were communicated to me by my ingenious Friend Mr. *Duncomb Smith*, who is very well ſkill'd in theſe things.

$$\left.\begin{array}{ll}
1. & y^4+fx^2y^2+gxy^3+hx^2y+iy^2+kxy+ly \\
2. & y^4+fxy^3+gx^2y+hxy^2+ixy+ky \;\ldots\ldots \\
3. & x^2y^2+fy^3+gx^2y+hy^3+ky \;\ldots\ldots \\
4. & x^2y^2+fy^3+gy^2+hxy+iy \;\ldots\ldots \\
5. & y^3+fxy^2+gx^2y+hy \;\ldots\ldots \\
6. & y^3+fxy^2+gxy+hy \;\ldots\ldots
\end{array}\right\} = ax^4+bx^3+cx^2+dx+e$$

$$\left.\begin{array}{ll}
7. & y^4+ex^3y+fxy^3+gxy^2+hy^2+ixy+ky \;\ldots \\
8. & x^3y+exy^3+fx^2y+gy^2+hxy+iy \;\ldots \\
9. & x^3y+ey^3+fxy^2+gxy+hy \;\ldots\ldots \\
10. & x^3y+ey^3+fy^2+gxy+hy \;\ldots\ldots
\end{array}\right\} = ax^3+bx^2+cx+d.$$

If it be ſo difficult to underſtand the Nature, Properties, and Number of the Curves of the ſecond and third Kinds, how much more ſo muſt it be to attain to a glimpſe of that infinite Number and Variety expreſſed by the Equations of the ſucceeding higher Dimenſions? And again, what an infinite Increaſe of Difficulty will ariſe in apprehending the Nature of the infinite-infinite Number of Curves which do not lie in the ſame Plane? When one duly conſiders this, it muſt be confeſſed that the moſt ſkilful and penetrating Mathematician poſſible, may

really be said to know little or nothing at all concerning the Nature of Curve Lines, however he may otherwise think.—Those who have a mind to see how far this Doctrine has been advanced, with regard to Curves of the higher Orders, as well as those of the first and second Orders, may consult Mr. *Mac-Laurin*'s *Organica Geometria*, and Mr. *Braikonridge*'s *Exercitatio Geometrica de Curvarum Descriptione*.

All geometrical Lines of the odd Order, *viz.* the third, fifth, seventh, *&c.* have at least one Leg running on infinitely; because all Equations of the odd Dimensions have at least one real Root. But vast Numbers of the Lines of the even Orders are only Ovals; amongst which there are several having very pretty Figures, some being like single Hearts, others double ones, others in figure of Fiddles, others again single Knots, double Knots, *&c.*

Two geometrical Lines of any Order will cut one another in as many Points as the Number expresses, which is produced by the Multiplication of the two Numbers expressing those Orders. And Mr. *Braikonridge*, in the Preface to his Treatise aforesaid, says, Mr. *George Campbell*, now Clerk of the Stores at *Woolwich*, has got a neat Demonstration of the same, which he hopes he will publish.

GEOMETRICAL PLANE. See *Plane*.

GEOMETRICAL PROGRESSION, or PROPORTION. See *Progression*.

GEOMETRICAL SOLUTION *of a Problem*, is when the Thing is solved according to the Rules of Geometry, and by such Lines as are truly geometrical, and agreeable to the Nature of the Problem.

GEOMETRIC PLACE, or LOCUS. See *Locus*.

GEOMETRY, originally signifies the Art of Measuring the Earth; but it is now the Science of whatever is extended, so far as it is such; that is, of Lines, Superficies, and Solids.

GEOMETRY, as related by *Proclus*, had its first rise in *Egypt*, where the *Nile* annually overflowing the Country, and covering it with Mud, obliged Men to distinguish their Lands one from another by the Consideration of their Figure; and to be able also to measure the Quantity of them, and to know how to plot it, and lay them out again in their just Dimensions, Figure, and Proportion; after which, 'tis likely a farther Contemplation of those Draughts and Figures helped them to discover many excellent and wonderful Properties belonging to them, which Speculation continually was improving, and is still to this very day. But the Geometry of the Ancients was contain'd within narrow Bounds, as well as their other Mathematical Speculations, for it only extended to right Lines and Curves of the first kind, or Order; whereas now Lines of infinite Orders are received in Geometry.

Geometry is divided into Speculative and Practical: The former treating of the Properties of Lines and Figures; such as *Euclid*'s *Elements*, *Apollonius*'s *Conics*, &c. And the latter shews how to apply these Speculations to Use in Life.

Plato thought the word *Geometry* a very ridiculous Name for this Science, and substituted in its place the more extensive Name of Mensuration; and after him, others gave it the Title of Pantometry. But this is too scanty; for it not only enquires into, and demonstrates the Quantities of Magnitudes, but also their Qualities, *viz.* Species, Figures, Ratio's, Positions, Transformations, Descriptions, Divisions,

how to find their Centres, Diameters, Tangents, Asymptotes, Curvatures, &c. some say it is the Science of enquiring, inventing, and demonstrating all the Affections of Magnitude. And *Proclus* calls it the Knowledge of Magnitudes and Figures, and their Limitations; also of their Ratio's, Affections, Positions, and Motions of every kind.

The Writings upon Geometry are very numerous; some speculative, and others practical. Amongst the former are the well-known Elements of *Euclid*, first wrote by him in *Greek* more than 2000 Years ago; but in these later Ages translated into various Languages. *Orontius Finæus*, *Anno* 1530, published a Commentary upon the first six Books; and so did *James Peletarius*, *Anno* 1557. *Nicolas Tartaglia* also published about the same time a Commentary upon all the 15 Books. After which *Clavius* did the like.

There is a *Greek* Commentary upon *Euclid*'s first Book by *Proclus*: As also those of *Campanus* and *Theon*, upon the whole Books. There are also *Commandine*'s, *Dee*'s, *Schubelius*'s, *Herlinus*'s, *Dasypodius*'s, *Ramus*'s, *Herigon*'s, *Barrow*'s, *Taquet*'s, *Dechales*'s, *Furnier*'s, and *Scarborough*'s *Euclid*, with many others too many to mention here. There are many modern Writers of the Elements of Geometry, as well as *Euclid*; such as *Borellus*, *Pardies*, *Arnald*, *Sturmy*, *Lamy*, *Polynier*, *Marchetti*, *Wolfius*, &c. Amongst those who have exceeded *Euclid* in the Elementary Geometry, we have *Archimedes* in his Treatises of the *Sphere and Cylinder*, of *the Dimension of the Circle*, of *Conoids* and *Spheroids*, of *Spirals* and the *Quadrature of the Parabola*. — *Kepler*, in his *Nova Stereometria Doliorum Vinariorum*. — *Cavalerius*, in his *Geometria Indivisibilium*. — *Torricellius*, in his *Opera Geometrica*. — *Viviani*, in his *Divinationes Geometricæ in quintum Librum Apollonii Pergei adhuc desideratum*. — *Theodosius*, in his *Spherics*. — *Serenius*, in his *Section of the Cone and Cylinder*. — *Gregory St. Vincent*, in his *Quadratura Circuli*; and many others. Add to these Dr. *Barrow*'s *Geometrical Lectures*. — *Bullialdus*'s, *Schooten*'s, and Dr. *Gregory*'s *Exercitationes Geometricæ*. — *De Billy*'s Treatise *de Proportione harmonica*. — *La Lovera*'s *Geometria veterum promota*. — *Viviani*'s *Exercitatio Mathematica*. — *Herberstein*'s *Diotome Circulorum*. — *Palma*'s *Exercitationes in Geometriam*. — *Apollonius de Sectione Rationis*. The Writers upon Practical Geometry, are *Clavius*, *Mallet*, *de la Hire*, *Taquet*, *Ozanam*, *Wolfius*, and many others, which I shall omit to mention.

Gibbous, is a Term used in reference to the enlighten'd Parts of the Moon, while she is moving from Full to the first Quarter, and from the last Quarter to the Full again; for all that time the dark Part appears horned and falcated, and the light one bunched out, convex or gibbous.

Girders, in Architecture, are the largest Pieces of Timber in a Floor. Their Ends are usually fasten'd into the Summer or Breast-Summers, and the Joists are framed in at one end to the Girders. No Girder should lie less than ten Inches into the Wall, and their Ends should be laid in Lome, &c.

Given, is a Word often used in Mathematics, and signifies something which is supposed to be known. Thus, if a Magnitude be known, or that we can find another equal to it, they say 'tis a given Magnitude. If the Position of any thing be supposed as known, they say, given in Position. Thus if a Circle be actually described upon

on any Plane, they say, its Centre is given in Position; its Circumference is given in Magnitude; and the Circle both in Position and Magnitude. But a Circle may be given in Magnitude only; as, when only its Diameter is given, but the Circle not actually described. If the Kind or Species of any Figure be given, they say, given in Species: If the Ratio between any two Quantities is known, they are said to be given in Ratio.

GLACIS, a sloping Bank in Fortification. It signifies a very gentle Steepness; but is more especially taken for that which rangeth from the Parapet of the cover'd Way, to the Level on the side of the Field.

GLOBE, the same as Sphere. Which see.

When a Globe has all the Parts of the Earth and Sea drawn or delineated on its Surface, like as on a Map, and placed in their natural Order and Situation, it is called an *artificial terrestrial Globe*.

But if upon the Superficies thereof, be painted the Images of the Constellations, and the fixed Stars, with the Circles of the Sphere, it is called an *artificial cœlestial Globe*.

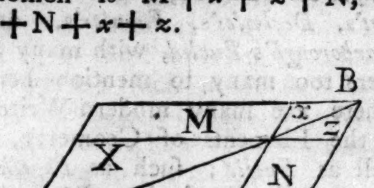
Both these Globes, in order to shew the Nature of the Sphere, and resolve Astronomical and Geographical Problems, are fitted and moveable in Brass Meridians, and these Meridians are set in Notches made in broad wooden Circles representing the Horizon.

GLOBULAR CHART, is a Name given to a Representation of the Surface, or some Part of the Surface of the terraqueous Globe upon a Plane, wherein the Parallels of Latitude are Circles nearly concentric; the Meridian's Curves bending towards the Poles, and the Rhumb-Lines also Curves.

This Chart is valuable upon this account, *viz.* that the Distances between Places upon the Rhumb are all measured by the same Scale of equal Parts, and the Distance of any two Places in the Arch of a great Circle, is nearly represented in this Chart by a straight Line; and so, if Land-Maps were made according to this Projection, they would, in my opinion, be better than those that are made any other ways whatsoever. But this Chart will never be of so excellent Use to Seamen, as *Mercator*'s; because the Meridians, Parallels, and particularly the Rhumb-Lines, being all Curves in the Globular Chart, but straight Lines in that of *Mercator*; straight Lines are vastly more easy to draw and manage than Curves, especially such as the Rhumb-Lines on the Globular Chart are.

This Projection is not new, but on the contrary very ancient; for it is mentioned by *Ptolemy* in his *Geography*; as also by *Blundevill*, in his *Exercises*.

GNOMON, in a Parallelogram, is a Figure made of the two Complements, together with either of the Parallelograms about the Diagonal; as in the Parallelogram A B, the Gnomon is $M+x+z+N$, or $M+N+x+z$.



GNOMON, in Dialling, is the Style, Pin or Cock of any Dial, whose Shadow shews the Hour. The Gnomon of every Dial represents the Axis of the World.

GNOMONIC PROJECTION *of the Sphere*, is the Representation of the Circles of the Sphere, upon a Plane that touches the Sphere, or else on one

on one that does not cut it, the Eye being ſuppoſed in the Centre of the Sphere.

In this Projection, (which all Plane Sun-Dials may be ſaid to be of, from whence it derives its Name, *viz.* from Gnomonics, or Dialling,) all the great Circles of the Sphere are repreſented by ſtraight Lines, of an indeterminate Length. All leſſer Circles, parallel to the Plane of Projection, will be Circles; and all leſſer Circles, oblique to the Projection-Plane, will be either Parabola's, Ellipſes, or Hyperbola's, according to their different Obliquity.

GNOMONICS. The ſame with *Dialling*.

GOLDEN NUMBER. See *Cycle of the Moon*.

If 1 be added to the Year, and the Sum be divided by 19, the Remainder, after Diviſion, is the *Golden Number*.

GOLDEN RULE. See *Rule of Three*.

GORGE, GULLA, or NECK, in Architecture, is the narroweſt Part of the *Tuſcan* or *Doric* Capitals, lying between the Aſtragal, above the Shaft of the Pillar, and the Annulets. It is alſo a kind of concave Moulding, larger, but not ſo deep as a *Scotia*, which ſerves for Compartments, *&c.*

GORGE, in Fortification, is the Entrance of the Platform of any Work.

GORGE, in all other Outworks, is the Interval betwixt the Wings on the Side of the great Ditch. But it ought to be obſerved, that all the Gorges are deſtitute of Parapets; becauſe, if there were any, the Beſiegers, having taken poſſeſſion of a Work, might make uſe thereof, to defend themſelves from the Shot of the Place; ſo that they are only fortified with Palliſadoes, to prevent a Surprize.

GORGE *of a Baſtion*, is nothing elſe but the prolonging of the Courtines from their Angle with Flanks, to the Centre of the Baſtion where they meet; but when the Baſtion is flat, its Gorge is a right Line, which terminates the Diſtance comprehended between two Flanks.

GORGE *of the Ravelin*, or *of a Half-Moon*, is the Space contained between the Extremities of the two Faces on the Side of the Place.

GOTHIC (or MODERN) ARCHITECTURE, is that which is far removed from the Manner and Proportions of the Antique, having its Ornaments wild and chimerical, and its Profiles incorrect. However, it is oftentimes found very ſtrong, and appears very rich and pompous, as particularly in ſeveral *Engliſh* Cathedrals. This manner of Building came originally from the North, whence it was brought by the *Goths* into *Germany*, and has ſince been introduced into other Countries.

GRANADO, is a little hollow Globe, or Ball of Iron, or other Metal, about two Inches and a half in Diameter, which being filled with fine Powder, is ſet on fire by the means of a ſmall Fuſee, faſtened to the Touch-Hole: As ſoon as it is kindled, the Caſe flies into many Shatters, much to the Damage of all that ſtand near. Theſe Granadoes ſerve to fire cloſe and narrow Paſſages, and are often thrown with the Hand among the Soldiers, to diſorder their Ranks; more eſpecially in thoſe Poſts where they ſtand thickeſt, as in Trenches, Redoubts, Lodgments, *&c.*

GRAVITY, is that Force by which Bodies are carried, or tend towards the Centre of the Earth.

GRAVITY (ABSOLUTE,) is the whole Force by which any Body tends towards the Centre of the Earth.

GRAVITY (ACCELERATE,) is the Force of Gravity conſider'd, as growing

growing greater, the nearer it is to the attracting Body or Point.

GRAVITY (RELATIVE,) is the Excess of the Gravity in any Body, above the specific Gravity of a Fluid it is in.

GRAVITATION, is a Pressure that a Body, by the Force of its Gravity, exerts on another Body under it.

1. All Bodies are mutually heavy, or gravitate mutually towards each other; and this Gravity is proportional to the Quantity of Matter; and at unequal Distances it is inversly, as the Square of the Distance. And so the Sun and Planets mutually gravitate towards each other; the Satellites of *Jupiter* and *Jupiter*; the Satellites of *Saturn* and *Saturn*; and the Moon and the Earth.

2. On the Surfaces of Bodies that are Spherical and Homogeneous, the Gravities will be in the Ratio compounded of the Densities and the Diameters.

3. If a Body be placed in a Sphere that is Homogeneous, Hollow, and every where of the same Thickness, it has no Gravity, let it be placed where it will.

4. In an homogeneous Sphere, Gravity decreases in coming towards the Centre, in the direct Ratio of the Distance from the Centre.

5. By Gravity all Bodies descend towards a Point, which either is, or is very near to the Centre of Magnitude of the Earth and Sea, about which the Sea forms itself into a spherical Surface; and the Prominences of the Land, considering the Bulk of the Whole, differ but insensibly therefrom.

6. This Point or Centre is fixed within the Earth, or at least hath been so ever since we have any authentic History. For a Consequence of its Shifting, tho' never so little, would be overflowing of the low Land on that Side of the Globe towards which it approached.

7. In all Places equi-distant from the Centre of the Earth, the Force of Gravity is nearly equal.

8. Gravity equally affects all Bodies, without regard to their Bulk, Figure, or Matter; so that abstracting from the Resistance of the Medium, the most compact and loose, the greatest and smallest Bodies would descend equal Spaces in equal Times, as appears from the quick Descent of very light Bodies in the exhausted Receiver.

9. There are various Opinions of Philosophers concerning the Cause of Gravity; but the most probable is, that of a very subtle Fluid, which encompasses the Earth and Air, that freely pervades the Pores of all Bodies: For the Endeavours of such a Fluid to detrude all earthly Bodies from it, together with some other Properties, may make all Bodies move towards the Centre of the Earth: And that there is such a Fluid, is shewn by Experiments.

10. Sir *Isaac Newton*, in his *Optics*, the last Edition, proposes the following Queries concerning that subtle Medium, which is the Cause of the Gravity and Attraction of Bodies.

1. If in two large tall Cylindrical Vessels of Glass inverted, two little Thermometers be suspended, so as not to touch the Vessels, and the Air be drawn out of one of these Vessels, and these Vessels thus prepared be carried out of a cold Place into a warm one, the Thermometer *in vacuo* will grow warm as much, and almost as soon as the Thermometer which is not *in vacuo*; and when the Vessels are carried back into a cold Place, the Thermometer *in vacuo* will grow cold almost as soon as the other Thermometer. Is not the Heat of the warm Room conveyed through the Vacuum by the Vibrations of a much subtler Medium than Air, which,

which, after the Air was drawn out, remained in the Vacuum? And is not this Medium the same with that Medium by which Light is refracted and reflected? and by whose Vibrations Light communicates Heat to Bodies, and is put into Fits of easy Reflexion and easy Transmission? And do not the Vibrations of this Medium in hot Bodies contribute to the Intenseness and Duration of their Heat? And do not hot Bodies communicate their Heat to contiguous cold ones, by the Vibrations of this Medium, propagated from them into cold ones? And is not this Medium exceedingly more rare and subtle than the Air, and exceedingly more elastic and active? And doth it not readily pervade all Bodies? And is it not (by its elastic Force) expanded through all the Heavens?

2. Doth not the Refraction of Light proceed from the different Density of this Ætherial Medium in different Places, the Light receding always from the denser Parts of the Medium? And is not the Density thereof greater in free and open Spaces, void of Air, and other grosser Bodies, than within the Pores of Water, Glass, Crystal, Gems, and other compact Bodies? For when Light passes through Glass, or Crystal, and falling very obliquely upon the farther Surface thereof, is totally reflected, the total Reflection ought to proceed rather from the Density and Vigour of the Medium without, and beyond the Glass, than from the Rarity and Weakness thereof.

3. Doth not this Ætherial Medium in passing thro' Water, Glass, Crystal, and other compact and dense Bodies into empty Spaces, grow denser and denser by degrees, and by that means refract the Rays of Light not in a Point, but by bending them gradually in Curve-Lines? And doth not the gradual Condensation of this Medium extend to some Distance from the Bodies, and thereby cause the Inflexions of the Rays of Light, which pass by the Edges of dense Bodies, at some distance from the Bodies.

4. Is not this Medium much rarer within the dense Bodies of the Sun, Stars, Planets, and Comets, than in the empty Celestial Spaces between them? And in passing from them to great Distances, doth it not grow denser and denser perpetually, and thereby cause the Gravity of those great Bodies towards one another, and of their Parts towards the Bodies; every Body endeavouring to go from the denser Parts of the Medium towards the rarer? For if this Medium be rarer within the Sun's Body than at its Surface, and rarer there than at the hundredth Part of an Inch from its Body, and rarer there than at the fiftieth Part of an Inch from its Body, and rarer there than at the Orb of *Saturn*; I see no reason why the Increase of Density should stop any where, and not rather be continu'd through all Distances from the Sun to *Saturn*, and beyond. And though this Increase of Density may at great Distances be exceeding slow, yet, if the elastic Force of this Medium be exceeding great, it may suffice to impel Bodies from the denser Parts of the Medium towards the rarer, with all that Power which we call *Gravity*. And that the elastic Force of that Medium is exceeding great, may be gathered from the Swiftness of its Vibrations. Sounds move about 1140 *English* Feet in a Second of Time, and in seven or eight Minutes of Time they move about one hundred *English* Miles. Light moves from the Sun to us in about seven or eight Minutes of Time, which Distance is about 70000000 *English* Miles; supposing the

the horizontal Parallax of the Sun to be about 12 sec. And the Vibrations or Pulſes of this Medium, that they may cauſe the alternate Fits of eaſy Tranſmiſſion and eaſy Reflexion, muſt be ſwifter than Light, and by conſequence above 700000 Times ſwifter than Sounds. And therefore the elaſtic Force of this Medium, in proportion to its Denſity, muſt be above 700000 × 700000 (that is above 490000000000) Times greater than the elaſtic Force of the Air, is in proportion to its Denſity. For the Velocities of the Pulſes of elaſtic Mediums are in a ſubduplicate Ratio of the Elaſticities and the Rarities of the Mediums taken together.

5. As Attraction is ſtronger in ſmall Magnets than in great ones, in proportion to their Bulk; and Gravity is greater in the Surfaces of ſmall Planets than in thoſe of great ones, in proportion to their Bulk; and ſmall Bodies are agitated much more by electric Attraction than great ones; ſo the Smallneſs of the Rays of Light may contribute very much to the Power of the Agent, by which they are refracted. And ſo, if any one ſhould ſuppoſe that Æther (like our Air) may contain Particles, which endeavour to recede from one another, (for I do not know what this Æther is,) and that its Particles are exceedingly ſmaller than thoſe of Air, or even thoſe of Light: The exceeding Smallneſs of its Particles may contribute to the Greatneſs of the Force, by which thoſe Particles may recede from one another, and thereby make that Medium exceedingly more rare and elaſtic than Air, and by conſequence exceedingly leſs able to reſiſt the Motions of Projectiles, and exceedingly more able to preſs upon groſs Bodies, by endeavouring to expand itſelf.

6. May not Planets and Comets and all groſs Bodies, perform their Motions more freely, and with leſs Reſiſtance in this Æthereal Medium, than in any Fluid, which fills all Space adequately, without leaving any Pores, and by conſequence is much denſer than Quickſilver or Gold? And may not its Reſiſtance be ſo ſmall, as to be inconſiderable? For inſtance, if this Æther (for ſo I will call it) ſhould be ſuppoſed 700000 Times more elaſtic than our Air, and above 700000 Times more rare, its Reſiſtance would be above 600000000 Times leſs than Water: And ſo ſmall a Reſiſtance would ſcarce make any ſenſible Alteration in the Motions of the Planets in ten thouſand Years. If any one would aſk how a Medium can be ſo rare, let him tell me how the Air, in the upper Parts of the Atmoſphere, can be above an hundred thouſand thouſand Times rarer than Gold? Let him alſo tell me how an electric Body can, by Friction, emit an Exhalation ſo rare and ſubtile, and yet ſo potent, as by its Emiſſion to cauſe no ſenſible Diminution of the Weight of the electric Body, and to be expanded through a Sphere, whoſe Diameter is above two Feet, and yet to be able to agitate and carry up Leaf-Copper, or Leaf-Gold, at the Diſtance of above a Foot from the electric Body? And how the Effluvia of a Magnet can be ſo rare and ſubtile, as to paſs through a Plate of Glaſs, without any Reſiſtance, or Diminution of their Force, and yet ſo potent, as to turn a magnetic Needle beyond the Glaſs?

7. Is not Viſion performed chiefly by the Vibrations of this Medium, excited in the bottom of the Eye, by the Rays of Light, and propagated through the ſolid, pellucid, and uniform Capillamenta of the optic Nerves into the Place of Senſation? And is not Hearing performed

formed by the Vibrations either of this or ſome other Medium, excited in the auditory Nerves by the Tremors of the Air, and propagated through the ſolid, pellucid, and uniform Capillamenta of thoſe Nerves into the Places of Senſation; and ſo of the other Senſes.

8. Is not animal Motion performed by the Vibrations of this Medium, excited in the Brain by the Power of the Will, and propagated from thence through the ſolid, pellucid, and uniform Capillamenta of the Nerves into the Muſcles, for contracting and dilating them? I ſuppoſe that the Capillamenta of the Nerves are each of them ſolid and uniform, that the vibrating Motion of the Æthereal Medium may be propagated along them from one End to the other uniformly, and without Interruption; for Obſtructions in the Nerves create Palſies. And that they may be ſufficiently uniform, I ſuppoſe them to be pellucid, when viewed ſingle, tho' the Reflections in their Cylindrical Surfaces may make the whole Nerve (compoſed of many Capillamenta) appear opake and white; for Opacity ariſes from reflecting Surfaces, ſuch as may diſturb and interrupt the Motions of this Medium.

9. The Parts of all homogeneal hard Bodies, which fully touch one another, ſtick together very ſtrongly: And for explaining how this may be, ſome have invented hooked Atoms, which is begging the Queſtion; and others tell us, that Bodies are glued together by reſt, that is, by an occult Quality, or rather by nothing; and others, that they ſtick together by conſpiring Motions, that is, by relative Reſt amongſt themſelves. I had rather infer from their Coheſion, that their Particles attract one another by ſome Force, which, in immediate Contact, is exceeding ſtrong, and at ſmall Diſtances performs the Chymical Operations of Fermentation, &c. and reaches not far from the Particles with any ſenſible Effect.

10. All Bodies ſeem to be compoſed of hard Particles; for otherwiſe Fluids would not congeal.

11. Even the Rays of Light ſeem to be hard Bodies.

12. Now if compound Bodies are ſo very hard, as we find ſome of them to be, and yet are very porous, and conſiſt of Parts, which are only laid together, the ſimple Particles which are void of Pores, and were never yet divided, muſt be harder; for ſuch hard Particles being heaped up together, can ſcarce touch one another in more than a few Points, and therefore muſt be ſeparable by a much leſs Force than is requiſite to break a ſolid Particle, whoſe Parts touch in all the Space between them, without any Pores or Interſtices to weaken their Coheſion. And how ſuch very hard Particles, which are only laid together, and touch only in a few Points, can ſtick together, and that ſo firmly as they do, without the Aſſiſtance of ſomething which cauſes them to be attracted or preſs'd towards one another, is very difficult to conceive.

13 The ſame thing I infer alſo from the cohering of two poliſhed Marbles *in vacuo*, and from the ſtanding of Quickſilver in the Barometer at the Height of fifty, ſixty, or ſeventy Inches, or above, whenever it is well purged of Air, and carefully poured in, ſo that its Parts be every where contiguous, both to one another, and to the Glaſs. The Atmoſphere by its Weight preſſes the Quickſilver into the Glaſs, to the Height of twenty-nine or thirty Inches: And ſome other Agent raiſes it higher, not by preſſing it into

into the Glaſs, but by making its Parts ſtick to the Glaſs, and to one another; for upon any Diſcontinuation of Parts, made either by Bubbles, or by ſhaking the Glaſs, the whole Mercury falls down to the Height of twenty-nine or thirty Inches.

14. Moreover, if two plain poliſhed Plates of Glaſs (ſuppoſe two Pieces of a poliſhed Looking-Glaſs) be laid together, ſo that their Sides be parallel, and at a very ſmall Diſtance from one another, and then their lower Edges be dipped into Water, the Water will riſe up between them; and the leſs the Diſtance of the Glaſſes is, the greater will be the Height to which the Water will riſe. If the Diſtance be about the hundredth Part of an Inch, the Water will riſe to the Height of about an Inch; and if the Diſtance be greater or leſs in any Proportion, the Height will be reciprocally proportional to the Diſtance, very nearly: For the attractive Force of the Glaſſes is the ſame whether the Diſtance between them be greater or leſs, and the Weight of the Water drawn up is the ſame, if the Height of it be reciprocally proportional to the Height of the Glaſſes. And, in like manner, Water aſcends between two Marbles, poliſhed plain, when their poliſhed Sides are parallel, and at a very little Diſtance from one another: And if ſlender Pipes of Glaſs be dipped at one End into ſtagnating Water, the Water will riſe up within the Pipes, and the Height to which it ariſes will be reciprocally proportional to the Diameter of the Cavity of the Pipe, and will be equal to the Height to which it riſes between two Planes of Glaſs, if the Semi-Diameter of the Cavity of the Pipe be equal to the Diſtance between the Planes, or thereabouts. And theſe Experiments ſucceed after the ſame manner *in vacuo*, as in the open Air, (as hath been tried before the Royal Society,) and therefore are not influenced by the Weight or Preſſure of the Atmoſphere.

15. If two plain poliſhed Plates of Glaſs, three or four Inches broad, and twenty or twenty-five long, be laid, one of them parallel to the Horizon, the other upon the firſt, ſo as at one of their Ends to touch one another, and contain an Angle of about ten or fifteen Minutes, and the ſame be firſt moiſten'd on their inward Sides, with a clean Cloth, dipped into Oil of Oranges, or Spirit of Turpentine, and a Drop or two of the Oil or Spirit be let fall upon the lower Glaſs at the other End; ſo ſoon as the upper Glaſs is laid down upon the lower, ſo as to touch it at one end as above, and to touch the Drop at the other end, making with the lower Glaſs an Angle of about ten or fifteen Minutes, the Drop will begin to move toward the Concourſe of the Glaſſes, and will continue to move with an accelerated Motion till it arrives at that Concourſe of the Glaſſes; for the two Glaſſes attract the Drop, and make it run that way towards which the Attraction inclines. And if, when the Drop is in motion, you lift up that End of the Glaſſes where they meet, and towards which the Drop moves, the Drop will aſcend between the Glaſſes, and therefore is attracted. And as you lift up the Glaſſes more and more, the Drop will aſcend ſlower and ſlower, and at length reſt, being then carried downward by its Weight, as much as upwards by the Attraction. And by this means you may know the Force by which the Drop is attracted at all Diſtances from the Concourſe of the Glaſſes.

16. There are therefore Agents in Nature able to make the Particles of Bodies ſtick together by very ſtrong Attractions. And it is the Buſineſs of expe-

experimental Philosophy to find them out.

Great Bear. See *Ursa Major*.

Great Circular Sailing, is the manner of conducting a Ship in, or rather pretty near the Arch of a great Circle, that passes through the Zenith of the two Places from whence, and to which she is bound.

Great Circles *of the Globe or Sphere*, are those whose Planes passing through the Centre of the Sphere, divide it into two equal Parts or Hemispheres: of which there are six drawn on the Globe, *viz* the Meridian, Horizon, Equator, Ecliptic, and the two Colures. Which see.

Gregorian Year. The new Account, or new Style, instituted upon the Reformation of the Kalendar, by Pope *Gregory* XIII. (from whom it takes the Name) in the Year 1582. Whereby ten Days being taken out of the Month of *October*, the Days of their Months go always ten Days before ours: As for instance, their eleventh is our first Day. Which new Style or Account, is used in most Parts beyond the Seas; and is called from Pope *Gregory*, the *Gregorian Account*.

Grenado. See *Grenado-Shell*.

Ground-Plates, in Architecture, are the outermost Pieces of Timber, lying on or near the Ground, and framed into one another with Mortesses, and Tennons of the Joists, the Summer and Girders; and sometimes the Trimmers for the Stair-Case and Chimney-way, and the Binding-Joists.

Guerite, in Fortification, is a small Tower of Wood or Stone, placed usually on the Point of a Bastion, or on the Angles of the Shoulder, to hold a Centinel, who is to take care of the Ditch and to watch out against a Surprize.

Gula, or Gullet. See *OEsophagus*.

Gulbe, in Architecture, the same as *Gorge*.

Gulf, in Geography, is such a Part of the Ocean, as runs up into the Land, thro' narrow Passages, or Streights; as the Gulf of *Florida*, in *America*; the *Arabian* Gulf, or *Red-Sea* in *Africa*; the *Persian* Gulf in *Asia*; the Gulf of *Venice*, or the *Adriatic* Sea in *Europe*.

Gunter's-Line, *or the Line of Numbers*, is the common Line of Numbers, invented by Mr. *Gunter*, a Professor of Geometry at *Gresham*-College. It is only the Logarithms laid off upon straight Lines; and its Use is for performing Operations of Arithmetic, by means of a Pair of Compasses, or even without, by sliding two of these Lines of Numbers by each other.

Gunter's Quadrant, is a Quadrant of Wood, Brass, &c. being partly a Stereographical Projection upon the Plane of the Equinoctial, the Eye being in one of the Poles, where the Tropic, Ecliptic, and Horizon, are Arches of Circles; but the Hour-Circles are all Curves drawn by means of the several Altitudes of the Sun for some particular Latitude every Day in the Year. The Use of this Instrument, is to find the Hour of the Day, the Sun's Azimuths, &c. and the other common Problems of the Globe; as also to take the Altitude of an Object in Degrees: But these Quadrants, as commonly sold by Instrument-Makers, are but of very little use, on account of their Inaccuracy, and the small Radius they are made to. They may indeed serve Country-Fellows to tell what is a-clock to half an Hour, or a Quarter perhaps; as likewise to amuse their ignorant Neighbours.

Note, This Quadrant is by no Means so good as *Collins*'s, in finding the Hour of the Day.

Gunter's-Scale, usually call'd by Seamen the *Gunter*, is a large plain Scale, with the Lines of artificial

tificial Sines, Tangents, and versed Sines, laid off upon straight Lines on it, so contrived to a Line of Numbers upon it, that by means of this Scale, and a pair of Compasses, all the Cases of plain and spherical Trigonometry may be solv'd tolerably exact, and consequently all Questions in Navigation, Dialling, *&c.* may be work'd by it.

The Name of this Scale is from the first Inventer Mr. *Gunter.* It is now commonly put upon Sectors, being there call'd *Artificial Lines.*

GUTTE, *or* DROPS, in Architecture, are certain Parts in figure of little Bells, which being six in Number, are placed below the Triglyphs, in the Architrave of the *Doric* Order. These are thus named from their Shape, resembling the Drops of Water, that having run along the Triglyphs, still hang under the Closure between the Pillars.

H.

HALF-MOON, in Fortification, is an Out-Work having only two Faces, forming together a Saliant-Angle, which is flank'd by some Part of the Place, and of the other Bastions.

HALF-MOONS are sometimes raised before the Courtains, when the Ditch is a little wider than it should be; and they are much the same as Ravelins, only the *Gorge* of the Half-Moon is made bending in, like a Bow, and most commonly covers the Point of a Bastion; whereas Ravelins are placed before the Courtain; but they are defective, as being not well flank'd.

HALF-TANGENT. See *Scale.*

HALO, *or* HALLO, is a certain Meteor, in figure of a bright Circle, encompassing the Sun, Moon, or a Star, especially the Moon.

These *Halo's* do sometimes appear colour'd, like the Rainbow: And Sir *Isaac Newton*, in his *Opticks*, gives a Hint at their Solution; where he shews that they arise from the Sun, or Moon's shining through a thin Cloud, consisting of Globules of Hail or Water, all of the same size.

HARMONICAL, *or* MUSICAL PROPORTION. Three or four Quantities are said to be in an Harmonical Proportion; when in the former Case, the Difference of the first and second shall be to the Difference of the second and third, as the first is to the third; and in the latter, the Difference of the first and second to the Difference of the third and fourth, as the first is to the fourth: For Example, 2, 3, and 6, are harmonically proportional: For 1 : 3 : : 2 : 6. If proportional Terms in the former Case are continu'd, there will arise an harmonical Progression.

If there be three Quantities in an harmonical Progression, the Difference between the second and twice the first, is to the first, as the second is to the third. Also the Sum of the first and last is to twice the first, as the last is to the middle one.

If there be four Quantities in an harmonical Proportion, the Difference between the second and twice the first, is to the first, as the third to the fourth.

HARMONY, is an agreeable or pleasant Union between two or more Sounds, continuing together at the same Time.

HEAD-ANGLES. See *Angles.*

HEAT, *in a hot Body*, is the Agitation of the Parts of the Body, and the Fire contained in it; by which Agitation a Motion is produced

duced in our Bodies, exciting the Idea of Heat in our Minds; and Heat, in reſpect of us, is only that Idea; and in the hot Body is nothing but Motion.

Heat, *in all Bodies*, is a Motion that may be infinitely diminiſh'd, and there may be ſuch a Motion, tho' it be not ſenſible to us, becauſe often we cannot diſcover any thing of Heat.

1. No Heat is ſenſible to us, unleſs the Body that acts upon our Organs of Senſe has a greater Degree of Heat than that of our Organs.

2. The Heat of a Body is not in proportion to the Quantity of Fire.

3. Several heated Bodies will become lucid, if their Heat be increaſed.

4. Heat may be ſo increaſed, that in ſome Bodies the Attracting Force is overcome by the Repelling Force; and in this Caſe the Particles fly from each other, and acquire an Elaſtick Force, ſuch as the Particles of Air have.

5. The Equinoctial Heat of the Sun, when he becomes Vertical, is as twice the Square of the Radius.

6. Under the Equinoctial, the Heat of the Sun is as the Sine of the Sun's Declination.

7. In the *Frigid Zones*, when the Sun ſets not, the Heat is as the Circumference of a Circle into the Sine of the Altitude: Theſe Aggregates of Warmth are as the Sines of the Sun's Declination; and at the ſame Declination of the Sun, they are as the Sines of the Latitudes; and generally they are as the Sines of the Latitudes into the Sines of the Declination.

8. The Equinoctial Day's Heat is every where as the Co-ſine of the Latitude.

9. In all Places where the Sun ſets, the Difference between the Summer and Winter-Heats, when the Declinations are contrary, is equal to a Circle into the Sine of the Altitude at Six, in the Summer-Parallel, and conſequently thoſe Differences are as the Sines of Latitude into, or multiplied by the Sines of the Declination.

10. The Tropical Sun under the Equinoctial has of all others the leaſt Force under the Pole: It is greater than any other Day's Heat whatſoever, being to that of the Equinoctial, as 5 to 4.

11. The Heat of the Sun for any ſmall Portion of Time, is always as a Rectangle, contain'd under the Sine of the Angle of Incidence of the Ray, producing Heat at that Time.

12. From the following Table, and theſe Properties of the Sun's Heat, we may have a general Idea, of that Part of Heat that ariſes ſimply from the Preſence of the Sun.

The Table ſhewing the Quantity of Heat to every 10th Degree of Latitude.

Lat.	*Sun in* ♈. ♎.	*Sun in* ♋.	*Sun in* ♑.
0	20000	18341	18341
10	19696	20290	15834
20	18797	21737	13166
30	17321	22651	10124
40	15321	23048	6944
50	12855	22991	3798
60	10000	22773	1075
70	6840	23543	000
80	3473	24675	000
90	0000	25055	000

But the different Degrees of Heat and Cold in differing Places, depend in a great meaſure upon the Accidents of the Neighbourhood of high Mountains, whoſe Height exceedingly chills the Air brought by the Winds over them; and of the Nature of the Soil, which variouſly retains the Heat, particularly the

 Sands,

Sand, which in *Africa, Arabia*, and generally where such sandy Desarts are found, do make the Heat of the Summer incredible to those that have not felt it.

HEGIRA, a Term in Chronology, signifying the *Epocha*, or Account of Time used by the *Arabians* and *Turks*, who begin their Computation from the Day that *Mahomet* was forced to make his Escape from the City of *Mecca*, which happen'd on *Friday July* 16. *A. D.* 622. under the Reign of the Emperor *Heraclius*.

HEIGHT *of a Figure*. See *Altitude of a Figure*.

HEIGHT *of the Pole*. See *Altitude of the Pole*.

HELIACAL RISING, is when a Star, having been under the Sun-Beams, gets out so as to be seen again.

HELIACAL-SETTING *of a Star*, is when it, by the near Approach of the Sun, first becomes inconspicuous. This is reckon'd in the Moon, but at seventeen Degrees distance, or thereabouts; but in other Stars, 'tis as soon as they get distant, or come near the Sun by the space of a whole Sign.

HELICE MAJOR *and* MINOR; the same with *Ursa Major* and *Minor*.

HELICOID PARABOLA, *or the* PARABOLIC SPIRAL, is a Curve which arises from the Supposition of the Axis of the common *Apollonian Parabola* being bent round into the Periphery of a Circle, and is a Line then passing through the Extremities of the Ordinates, which do now converge towards the Centre of the said Circle.

1. Suppose the Axis of the common Parabola to be bent into the Periphery of the Circle BDM, then the Curve B F G N A which passes through the Extremities of the Ordinates C F, D G, which converge

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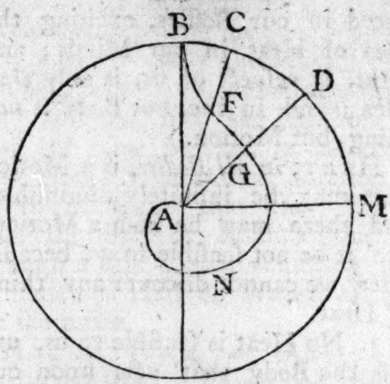


towards the Centre A of the Circle, is what is call'd the *Helicoid*, or *Spiral Parabola*.

2. If the Arch B C, as an Absciffe, be called x; and the Part C F of the Radius, as an Ordinate to it be called y; then the Nature of this Curve will be express'd by $lx = yy$; supposing l equal to the *Latus Rectum* of the Parabola.

AELICOSOPHY, is the Art of delineating all Sorts of Spiral Lines *in Plano*.

HELIOCENTRIC PLACE *of a Planet*, is that Point of the Ecliptic to which the Planet, seen from the Sun, is referred, and is the same as the Longitude of the Planet seen from the Sun.

HELIOSCOPES, are a sort of Telescopes fitted so, as to look on the Body of the Sun without Offence to the Eyes.

1. Because the Sun may be seen through colour'd Glasses without Hurt to the Eye; therefore, if the Object and Eye-Glasses of a Telescope be made with colour'd Glass, as Red and Green, and equally colour'd and pellucid, that Telescope will become a Helioscope.

2. But Mr. *Huygens* only used a plain Glass blacked at the Flame of a Lamp or Candle on one Side, and placed between the Eye-Glass and the Eye, and that will answer the Design of an Helioscope very well.

HELISPHERICAL LINE, is the Rhumb-

Rhumb-Line in Navigation; and is so called, because on the Globe it winds round the Pole spirally, and still comes nearer and nearer to it. See more of this under *Rhumb Line*.

HELIX, in Geometry, is the same as Spiral. Which see.

HEMISPHERE, is the Half of the Globe or Sphere, when 'tis supposed to be cut through the Centre in the Plane of one of its greatest Circles. Thus the Equator divides the Terrestrial Globe into the Northern and Southern Hemisphere; and the Equinoctial, the Heavens after the same Manner.

1. The Centre of Gravity of a Hemisphere, is five Eighths of the Radius distant from the Vertex.

2. The Horizon also divides the Earth into two Hemispheres, the one light, and the other dark, according as the Sun is above or below that Circle.

3. Also Maps or Prints of the Heavens, Constellations, &c. pasted on Boards, are sometimes called *Hemispheres*, but usually *Planispheres*.

4. The Writers of Optics prove, That a Glass-Hemisphere unites the Parallel Rays at the Distance of a Diameter and one Third of a Diameter from the Pole of a Glass.

HEMITONE, in Music, was what we now call an *Half-Note*.

HENDECAGON, in Geometry, is a Figure that hath eleven Sides, and as many Angles.

HENDECAGON, in Fortification, is taken for a Place defended by eleven Bastions.

HENIOCHUS, one of the Northern Constellations. See *Auriga*.

HEPTAGON, in Geometry, is a Figure of several Sides and Angles; and is called a *Regular Heptagon*, if those Sides and Angles be equal.

HEPTAGON, in Fortification, is taken for a Place that hath seven Bastions for its Defence.

HEPTANGULAR FIGURE, in Geometry, is that which consisteth of seven Angles.

HERISSON, in Fortification, is a Beam armed with a great Quantity of small Iron Spikes or Nails, having their Points outward, and is supported by a Pivot, upon which it turns, and serves instead of a Barrier to block up any Passage. They are frequently placed before the Gates, and more especially the Wicket-Doors of a Town or Fortress, to secure those Passages which must of necessity be often opened and shut.

HERMETICAL SEALING, or HERMES's SEAL, *or to seal or stop up any Glass hermetically*, is to heat the Neck of the Glass till it be just ready to melt, and then with a Pair of hot Pinchers to pinch or close it together.

HERMITAN, is the Name of a dry North and North-Easterly Wind, which usually blows on the Coasts of *Guinea* in *Africa*; but sometimes it blows also from other Points.

HERSE, in Fortification, is a Lettice, or Portcullice, made in the form of a Harrow, and beset with many Iron Spikes. It is usually hung by a Cord fasten'd to a Moulinet, which is cut in case of a Surprize; or when the first Gate is broken with a Petard, to the End that the Herse may fall, and stop up the Passage of the Gate, or other Entrance of a Fortress. These Herses are also often laid in the Roads to incommode the March, as well of the Horse as of the Infantry.

HERSILLON, in Fortification, is a Plank stuck with Iron Spikes, for the same Use as the Herse.

HETERODROMUS VECTIS, or LEAVER, in Mechanics, is that where the Hypomochlion is placed between the Power and the Weight;

and

and where the Weight is elevated by the Descent of the Power, and contrariwise.

HETEROGENEAL NUMBERS, are mix'd Numbers, consisting of whole ones, (or Integers,) and of Fractions.

HETEROGENEAL SURDS, are such that have different Radical Signs; as $\sqrt[2]{aa}$, $\sqrt[5]{bb}$, $\sqrt[3]{9}$, $\sqrt[7]{18}$, &c.

If the Indexes of the Powers of the Heterogeneous Surds be divided by their greatest common Divisor, and the Quotients be set under the Dividends; and those Indexes be multiplied crosswise by each other's Quotients; and before the Products be set, the common Radical Sign $\sqrt{}$, with its proper Index; and if the Powers of the given Roots be involved alternately according to the Index of each other's Quotient, and the common Radical Sign be prefix'd before those Products, then will those two Surds be reduced to others, having but one common Radical Sign. As to reduce

$\sqrt[2]{aa}$ and $\sqrt[4]{bb}$.

2) $\sqrt{aa}$ (2 $\sqrt[4]{bb}$.

1 X 2

$\sqrt[4]{bb}$ $\sqrt[4]{aaaa}$.

HETEROGENEAL LIGHT, by Sir *Isaac Newton*, is said to be that which consists of Rays of different Degrees of Refrangibility: Thus, the common Light of the Sun or Clouds is heterogeneal, being a Mixture of all sorts of Rays.

HETEROGENEOUS PARTICLES, are such as are of different Kinds, Natures, and Qualities, of which generally all Bodies consist.

HETEROSCII, in Geography, are such Inhabitants of the Earth as have their Shadows falling but one Way; as those who live between the Tropicks and Polar Circles, whose Shadows at Noon in North Latitude, are always to the Northward, and in South Latitude to the Southward.

HEXACHORD, a certain Interval or Concord of Music, commonly called a *Sixth*; and is twofold, *viz.* the Greater and Lesser.

The greater Hexachord is composed of two greater Tones, two lesser Tones, and one greater Semi-Tone, which are five Intervals; but the lesser Hexachord consists only of two greater Tones, one lesser Tone, and two greater Semi-Tones.

The Proportion of the former, in Numbers, is as 3 to 5; and that of the latter, as 5 to 8.

HEXAGON, in Geometry, is a Figure of six Sides and Angles; and if those Sides and Angles be equal, 'tis called a *Regular Hexagon*.

The Side of every Regular Hexagon inscribed in a Circle, is equal in Length to the Radius of that Circle.

As 1 is to 1.672, so is the Square of the Side of any Regular Hexagon to the Area thereof nearly.

HEXAHEDRON, one of the *Platonic* Bodies, is the same as the Cube, being a regular Solid of six equal Sides or Faces.

HEXASTYLE, an antient Building, which had six Columns in the Face before, and six also behind, and is the same with the Pseudodipteron.

HIP-ROOF, in Architecture, is such a Roof as hath neither Gable-Heads, Shred-Heads, nor Jerkin-Heads. These Hip-Roofs, by some, are called *Italian Roofs*.

HIPPEUS, *or* EQUINUS, a Comet which some will needs have to resemble a Horse. But the Shape of this kind of Comet is not always alike, as being sometimes Oval, and sometimes imitating a Rhomboides.

Its

Its Train, in like manner, is sometimes spread from the Front or Fore-Part; and at other Times from the Hinder-Part: Therefore they are distinguished into *Equinus Barbatus*, *Equinus Quadrangularis*, and *Equinus Ellipticus*.

HIPS, in Architecture, are those Pieces of Timber which are at the Corners of a Roof. They are a good deal longer than the Rafters, because of their oblique Position, for they are level at every Angle.

HIRCUS, a fixed Star, the same with *Capella*.

HIRCUS, a Name given by some to a Sort of a Comet encompassed by a kind of Mane, seeming to be rough and hairy, by reason of its Rays appearing like Hair. It is also sometimes without any Train or Bush.

HOBITS, are a sort of small Mortars from six to eight Inches diameter: Their Carriages are like those of Guns, only much shorter. They are very good for annoying the Enemy at a distance with small Bombs, which they will throw two or three Miles; or in keeping of a Pass, being loaded with Cartouches.

HOLLOW-TOWER, in Fortification, is a Rounding made of the Remainder of two Brizures, to join the Curtain to the Orillon, where the small Shot are play'd, that they may not be so much exposed to the View of the Enemy.

HOMOCENTRIC. The same with *Concentric*.

HOMODROMUS VECTIS, *or* LEAVER, is one where the Weight is in the middle between the Power and the Fulcrum, or the Power in the middle between the Weight and the Fulcrum.

HOMOGENEAL, signifies of the same Kind or Sort, or that which differs not in Nature, *&c.* The same with *Homogeneous*.

HOMOGENEAL NUMBERS, are those of the same Nature and Kind.

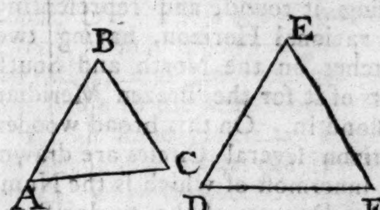
HOMOGENEAL SURDS, are such as have one common Radical Sign; as $\sqrt[2]{a}$, $\sqrt[2]{b}$, or $\sqrt[3]{b^3}$, or $\sqrt[3]{c^6}$, $\sqrt[3]{c^6}$.

HOMOGENEOUS PARTICLES, are such as are all of the same Kind, Nature, and Properties; as the Parts of pure Water, of meer Earth without Salt in it, or the Parts of the finer Metals; such as Gold, Silver, *&c.* 'Tis used in opposition to Heterogeneous; which see.

HOMOGENEAL LIGHT, is that whose Rays are all of one Colour, and Degree of Refrangibility, without any Mixture of others. See *Colours*.

HOMOGENEUM COMPARATIONIS, by *Vieta*, is the absolute Number in a Quadratic, or Cubic, *&c.* Equation; and this Number always possesseth one Side of the Equation, and is the Product of the Roots multiplied into one another.

HOMOLOGOUS SIDES OR ANGLES *of two Figures*, are those that keep the same Order from the Beginning in each Figure; as in the two similar Triangles ABC, DEF,



the Sides AC, DF; AB, DE; BC, EF; as also the Angles A, D; B, E; C, F, are Homologous.

HOOP-WHEEL. See *Detent-Wheel*.

HORIZON, is that great Circle which divides the Heavens and the Earth into two Parts, or Hemispheres, distinguishing the Upper from the Lower. It is either Sensible or Apparent, or the Rational or True Horizon.

1. The Senſible or True Horizon is that Circle which limits our Light, and may be conceived to be made by ſome great Plane, or the Surface of the Sea.

2. It divides the Heavens and Earth into two Parts; the one light, and the other dark; which are ſometimes greater or leſſer, according to the Condition of the Place, *&c.*

3. It determines the Riſing and Setting of the Sun, Moon, or Stars in any particular Latitude; for when any one of theſe appears juſt at the Eaſtern Part of the Horizon, we ſay it riſes; and when it doth ſo at the Weſtern Part, we ſay it ſets. And from hence alſo the Altitude of the Sun or Stars is accounted, which is their Height above the Horizon.

HORIZON *Rational, Real,* or *True,* is a Circle which encompaſſes the Earth exactly in the Middle, and whoſe Poles are the Zenith and Nadir; that is, the two Points, one exactly over our Heads, and the other under our Feet.

HORIZON *on the Globe,* or *Sphere,* is a broad Wooden Circle encompaſſing it round, and repreſenting the rational Horizon, having two Notches on the North and South Parts of it for the Brazen Meridian to ſtand in. On this broad wooden Horizon ſeveral Circles are drawn, the innermoſt of which is the Number of Degrees of the twelve Signs of the Zodiac, *viz.* thirty Degrees to each Sign.

Next to this you have the Names of thoſe Signs: then the Days of the Month, according to the *Julian* Account, or Old Style, with the Kalendar according to the Foreign Account, called *New Style*; and without theſe is a Circle divided into thirty-two equal Parts, which make thirty-two Rhumbs, or Points of the Mariner's Compaſs, with the firſt Letters of their Names annex'd

The Uſes of this Circle on the Globe are,

1. To determine the Riſing and Setting of the Sun, Moon, or Stars; and to ſhew the Time thereof by the Hour-Circle and the Index.

2. To limit the Increaſe and Decreaſe of Day and Night: For when the Sun riſes due Eaſt, and ſets Weſt, the Days and Nights are equal; but when he riſes and ſets to the North of the Eaſt and Weſt, the Days are longer than the Nights; but the Nights are longer than the Days, when the Sun riſes and ſets to the Southward of the Eaſt and Weſt Points of the Horizon.

3. To ſhew the Amplitude and Point of the Compaſs the Sun riſes and ſets upon.

HORIZONTAL LINE, *or* BASE *of a Hill,* is the Line AB drawn

upon a Plane parallel to the Horizon whereon the Hill is ſuppoſed to ſtand.

HORIZONTAL DIAL, is one whoſe Plane is parallel to the Horizon of any Place.

In all Horizontal Dials the Style makes an Angle equal to the Latitude of the Place, and the Angles that the Hour-Lines make with the Meridian, may be found by this Proportion: As the Radius is to the Sine of the Latitude, ſo is the Tangent of any Hour's Diſtance from 12 to the Tangent of the Angle that the Hour-Line of that Hour makes with the Hour-Line of 12.

The Reaſon of this Proportion for finding the ſeveral Hour-Angles, will

will appear from what is ſaid under the Word *Direct Erect South or North Dials*, for in the Figure there, in the right-angled Spherical Triangle A V R, we have given the Angle A R V for the Hour, and the Side A R for the Latitude; to find the Side A V, being the Angle that the Hour-Line of the given Hour makes with the Meridian upon the Plane of the Dial.

Horizontal Dials may be drawn Geometrically, after the very ſame manner as direct or erect South or North Dials. See the Figures for this purpoſe under theſe Words. Only in this Caſe the Angle A D C muſt be made equal to the Latitude, and not the Complement.

HORIZONTAL LINE, is any Line drawn parallel to the Horizon upon a Plane.

HORIZONTAL LINE *of a Dial*, is a right Line drawn through the Foot of the Style parallel to the Horizon.

HORIZONTAL PARALLAX. See *Parallax*.

HORIZONTAL PROJECTION. S e *Projection*.

HORIZONTAL RANGE, or LEVEL RANGE *of a Piece of Ordnance*, is the Line that a Ball deſcribes parallel to the Horizon or Horizontal Line when the Piece is level.

1. The Horizontal Ranges are the ſhorteſt. And ſome Pieces of Cannon will make them ſix hundred Paces, and ſome but a hundred and fifty; and the Ball, with the Range of ſix hundred Paces, will go from nine to thirteen Foot into the Earth.

HORN-WORK, in Fortification, is an Outwork, which advanceth toward the Field, carrying in the Forepart, or its Head, two Demi-Baſtions, in Form of Horns: Theſe Horns, Epaulments, or Shoulderings being joined by a Curtain, ſhut up on the Side by two Wings, parallel one to another, are terminated at the Gorge of the Work, and ſo preſent themſelves to the Enemy.

HOROLOGIOGRAPHY, is the Art of making Dials, Clocks, or other Inſtruments to ſhew the Time of the Day.

HOROMETRY, is the Art of meaſuring or dividing the Hours, and keeping account of Time.

HOROPTER, in Optics, is a right Line drawn through the Point of Concurrence, parallel to that which joins the Centre of the Eye.

HOROSCOPE, in Aſtrology, ſignifies the firſt Houſe, or Aſcendant, and is that Part of the Zodiac which is riſing at the time of the Calculation of a Scheme.

HORSE-SHOE, in Fortification, is a Work of a round, and ſometimes oval Figure, raiſed in the Ditch of a marſhy Place, or in low Ground, and bordered with a Parapet. It is made to ſecure a Gate, or to ſerve as a Lodgment for Soldiers to prevent Surprizes, or to relieve an over-tedious Defence.

HOUR, is the twenty-fourth Part of a natural Day, containing ſixty Minutes, and each Minute ſixty Seconds, &c. Theſe are aſtronomical Hours, which always begin at the Meridian, and are reckoned from one Noon to the next Noon.

1. But ſome Hours are begun to be accounted from the Horizon; which, when the Account begins at the Sun's Riſing, are called *Babyloniſh Hours*, which begin with the Sun's Riſing, and reckon on twenty-four Hours to his Riſing again the next Day.

2. Others are reckon'd after the ſame manner, only they begin at the Sun's Setting inſtead of his Riſing; and theſe are called *Italian Hours*, becauſe the *Italians* account their Time after this faſhion.

3. There is yet another kind of Hours, which are called *Jewiſh Hours*; becauſe of old the *Jews* accounted

accounted their time this way. They are one twelfth Part of the Day or Night, reckoned from the Sun-rising to the Sun-setting, (if the Days or Nights be long or short;) and these were called, as we find in the Holy Scripture, the *First*, *Second*, and *Third*, &c. *Hours of the Day or Night*.

HOUR-CIRCLES, the same with Meridians, are great Circles, meeting in the Poles of the World, and crossing the Equinoctial at right Angles. They are drawn through every fifteenth Degree of the Equinoctial and Equator, and on both Globes are supplied by the Meridian, Hour-Circle, and Index.

The Planes of the Hour-Circles are perpendicular to the Plane of the Equinoctial, which they divide into twenty-four equal Parts.

HOUR-LINES *on a Plane Dial*, are the Intersections of the Plane of the Dial, with the Planes of the Hour-Circles of the Sphere.

HOUR-SCALE, is a divided Line on the Edge of *Collins*'s Quadrant, being only two Lines of Tangents of forty-five Degrees each, set together in the middle; and the Use of it, together with the Lines of Latitudes, is to draw the Hour-Lines of Dials that have Centres, by means of an equilateral Triangle, drawn on the Dial-Planes.

HURDLES, or CLAYS, in Fortification, are made of thick and small Twigs of Willow, or Osiers, being five or six Foot high, and from three to four Foot broad. They are interwoven very close together, and usually laden with Earth, that they may serve to render Batteries firm, or to consolidate the Passage over muddy Ditches, or to cover Traverses and Lodgments for the Defence of the Workmen against the artificial Fires or Stones that may be cast upon them.

HYALOIDES, is the virtreous Humour of the Eye contain'd betwixt the Tunica-Retina and the Uvea.

HYBERNAL OCCIDENT. See *Occident*.

HYBERNAL ORIENT. See *Orient*.

HYDATOIDES, is the watery Humour of the Eye contained betwixt the Tunica-Retina and the Uvea.

HYDRA, a Southern Constellation, consisting of twenty-six Stars, and imagined to represent a Water-Serpent.

HYDRAULICS, is the Science of the Motion of Fluids, especially Water, under which is contain'd the Structure of all Fountains, Engines to carry or raise Water, or which are mov'd by Water, and some for other Uses.

Some of the Writings upon Hydraulics and Hydrostatics, are *Archimedes*, in his *Libris de Insidentibus humido*.— *Marinus Ghetaldus*, in his *Archimedes promotus*.—— Those of Mr. *Oughtred*.—Mr. *Mariotte*, in his *Treatise of the Motion of Water, and other Fluids*.— Mr. *Boyle*, in his *Hydrostatical Paradoxes*.—— *Franciscus Tertius de Lanis*, in his *Magisterium Naturæ & Artis*.—— Mr. *Lamy*, in his *Traité de l'Equilibre des Liqueurs*. —Those of Mr. *Rohault*.—Dr. *Wallis*, in his *Mechanics*.— Those of Mr. *Dechales*.— Sir *Isaac Newton*, in lib. 2. of his *Princip. Philos. Nat.* — *Johannes Ceva*, in his *Geometria Motus*.—Those of *Johannes Baptista Balianus*.— Mr. *Gulielmeni*, in his *Mensura Aquarum Fluentium*.—— Those of Mr. *Herman*.— Those of Mr. *Wolfius*.— Mr. *s'Gravesande*. — Mr. *Muschenbroek*.—Mr. *Leopold*. — *Hero* of *Alexandria*, his *Liber Spiritalium*, translated by *Commandine* into *Latin*.— *Salomon de Caus*, in his *French* Book of Machines.— *Casper Schottus*, his *Mechanica Hydraulico-Pneumatica*.— *George Andrea*

drea Bockler in his *Architectura Curiosa Germanica.* — *Augustine Rammilleis.*—*Lucas Antonius Portius.*—*Sturmy* in his *German* Treatise of the Construction of Mills.—*Switzer*, &c.

HYDRAULICO-PNEUMATICAL ENGINES, are those that raise Water by means of the Spring, or natural Force of the Air.

HYDROGRAPHICAL CHARTS, are certain Sea-Maps, delineated for the Use of Pilots and other Mariners; wherein are marked all the Rhumbs or Points of the Compass, and Meridians parallel to one another, with Shelves, Shallows, Rocks, Capes, *&c.*

HYDROGRAPHY, is an Art which teacheth how to describe and measure the Sea; giving an Account of its Tides, Counter-Tides, Soundings, Bays, Creeks, *&c.* as also Rocks, Shelves, Sands, Shallows Promontories, Harbours, Distance from one place to another, and other Things remarkable on the Coasts.

HYDROSTATICS, is the Science of the Gravitation of Fluids, and of their Action, when demersed in Solids.

This is a Part of Philosophy which ought to be looked upon as the most ingenious of any, the Theorems and Problems of this Art being handsome Productions of Reason, and affording Discoveries not only pleasing, but also surprisingly wonderful and useful.

HYDROSTATICAL BALLANCE. See *Ballance.*

HYEMAL SOLSTICE. See *Solstice.*

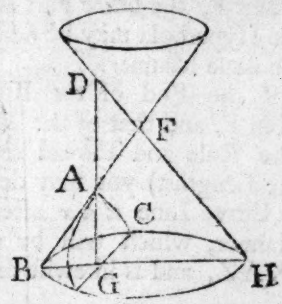
HYGROMETER, is a Philosophical Instrument, which measures the Dryness and Moisture of the Air.

HYGROSCOPE, is an Instrument shewing the Increase and Decrease of the Dryness of the Air.

The Hygroscope of Mr. *Molyneux*, being a very simple and good one, is made thus:

Fasten a Piece of Whipcord, of about four Foot long, to a Hook or Staple, in some convenient Place of the Ceiling of a Room, and at the bottom hang a Weight of about a Pound; let thereon, or unto the bottom of the Weight, be fastened an Index of about a Foot long, and under it, on a Table, or on a Piece of Board, place a Circle, divided into what Number of Degrees you please, and fit it so that the Centre of the Index may hang just over the Centre of the Circle. After it has hung thus two or three Days, to stretch the Cord, you may begin to measure by it the Degrees of Moisture or Drought in the Air; for the Cord will twist one way, and contract itself for wet, and untwist itself again on the contrary way for dry.

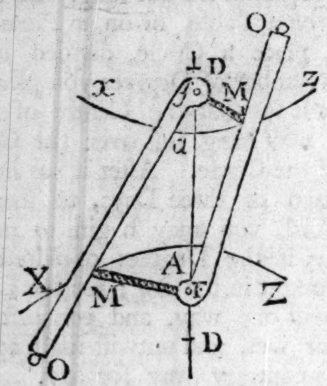
HYPERBOLA, is a Curve made by cutting a Cone by a Plane that falls within the Circular Base of the Cone, being neither parallel to the Side of the Cone, nor cuts it thro' the Vertex, and which Plane, if continued, will cut the opposite Cone. As the Curve CAG is an Hyperbola, if the



Plane AG, continu'd out, cuts the opposite Cone in D, and is not parallel to the Side FH, nor does pass through the Vertex E.

1. If one End of a long Rule *f*MO be fastened in the Point *f*, taken on a Plane, in such a manner, that it may turn freely about that fixed Point *f*, as a Centre; and one End of the Thread FMO (being in Length less than the said Rule) be fixed to O, the other End of the Rule, and the other End of the Thread be fixed in the Point F, taken on the Plane; then if the Rule *f*MO be turned about the fixed Point

Point f; and at the same time you keep the Thread OMF always in an equal Tension, and its Part MO

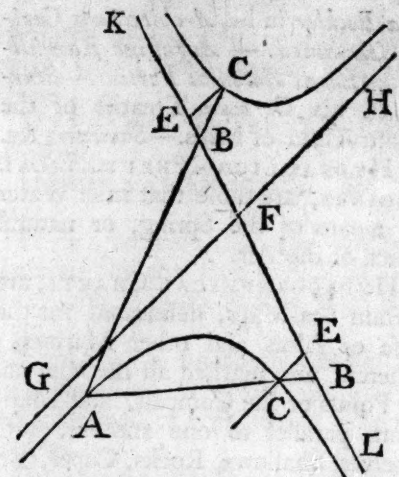


close to the Side of the Rule, by means of the Pin M; the Curve Line AX describ'd by the Motion of the Pin M, is one Part of an Hyperbola.

And if the Rule be turned about, and moves on the other Side of the fixed Point F, the other Part AZ of the same Hyperbola may be describ'd after the same Manner.

But if the End of the Rule be fastened in F, and that of the Thread in f, (the Rule and Thread keeping the same Lengths,) you may describe another Curve Line $z\,a\,x$ after the same Manner, which will be opposite to XAZ, and is likewise an Hyperbola.

The following Description of an Hyperbola by a continued Motion, being that of Mr. *De Witt*'s, in his *Elementa Linearum Curvarum*, is pretty enough. Let KL, GH be the Asymptotes, take the Point A between them, and having fasten'd a Ruler AB to the Point B in the Side EB of a given Angle CEB, move the Side EB of that given Angle along the Line KL, always co-inciding with it; then if the Rule AB be at the same time carried about the fix'd Point A upon the Plane; the Intersection C of that Rule with



the other Side EC of the given Angle CEB, will describe an Hyperbola.

Otherwise by means of Points. Let AB, DE, (*Fig.* 1.) be the Axes in-

Fig. 1.

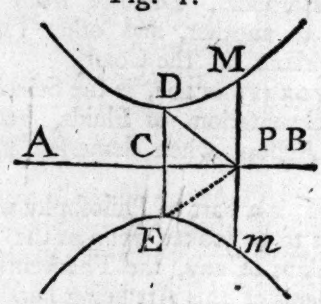
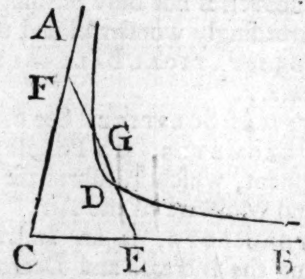


Fig. 2.



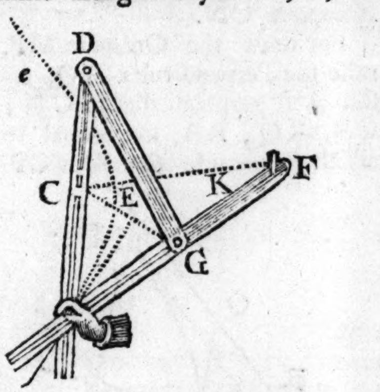
tersecting one another in C; take any Point P in AB, and from D or E draw the right Line DP, or EP; then thro' P draw the right Line Mm parallel to DE, and make PM, and Pm each equal to DP or EP; then will the Points M, m be two

Points

Points of the opposite Hyperbola's: and thus may an infinite Number of Points be found. Or (*Fig.* 2.) let AC, CB be the Asymptotes, and D a given Point. Draw any right Line EF thro' the Point D, terminating in the Asymptotes, and make FG, equal to DE, then will the Point G be one Point thro' which an Hyperbola is to pass; and thus may any Number of Points be found; and of all Ways to describe an Hyperbola by means of Points, this is the easiest.

2. If there be given the two Foci C, F, of an Hyperbola, and the Vertex E, and it is requir'd to describe an Hyperbola to these Foci and Vertex.

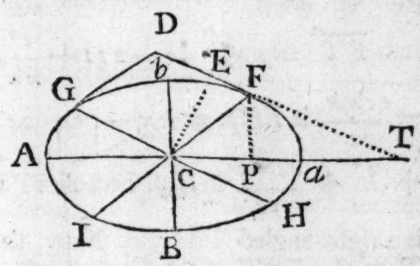
Let KF=CE, so that EK be the transverse Axis, and take three Rules CD, DG, and GF, so that CD=GF=EK, and DG=CF. Let the Rules CD, GF, be of an indefinite Length beyond C, D, and

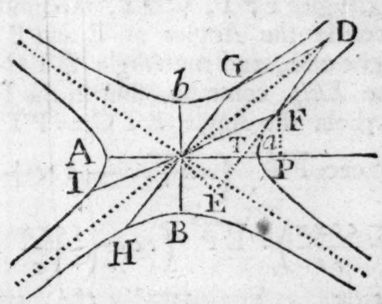


have Slits in them the Breadth of the Pin that is to describe the Hyperbola. Moreover, let these Rules have Holes made in them at C, F, in order to fasten them to the Foci C and F, by means of Points, and at the Places DG, they are to be joined by the Rule DG. This being done, if a Pin be put in the Slits, *viz.* the common Intersection of the Rules CD, GF, and mov'd along, causing the two Rules GF, CD, to turn about the Foci C, F, that Pin will describe the Portion E*e* of an Hyperbola.

3. *Any Parallelogram describ'd about an Ellipsis, or between the Conjugate Hyperbola's, so that the four Points of Contact may be join'd by two Diameters* GH, IF *only, which therefore will be Conjugates, is equal to the Parallelogram describ'd about the two Axes* Aa, Bb; *and consequently all such Parallelograms, are equal to one another.*

From F, the Extremity of one Diameter, draw the Line FD parallel to the other Diameter GH, (continued out in the opposite Hyperbola's,) meeting the Axis (produced in the Ellipsis) in the Point T and from G the Extremity of the Diameter GH draw the Line GD parallel to the Diameter IF, meeting DF in





D: And from the Point F let fall the Perpendicular FP to the Axis A*a*; then GD, DF, will touch the Ellipsis, and the Hyperbola's *b*G, *a*F in G, F, the Extremities of the Conjugate Diameters; and so the Parallelogram CGDF will be one Fourth of that described about the Ellipsis, or between the Conjugate Hyperbola's, having the Condition mentioned

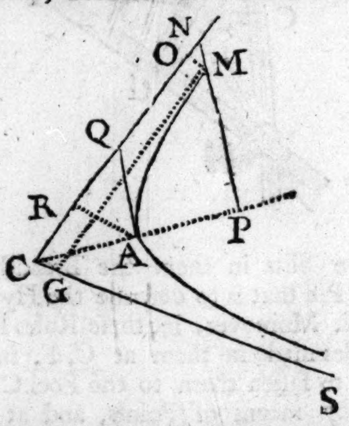
in

in the Theorem: Therefore, if CE be drawn perpendicular to DF, (produced in the Conjugate Hyperbola's,) we are to prove that CG ($=$ DF) $\times$ CE is $= Cb \times Ca = \frac{1}{4}$ of the Rectangle under the two Axes.

4. Call Ca, t, Cb, c, and Cp, x, then $\overline{Ca}^2$ (tt) : $AP \times Pa$ $(tt - xx$ in the Ellipsis, or $xx - tt$ in the Hyperbola) : : Cb (cc) : $\overline{FP}^2 = cc - \frac{ccxx}{tt}$. In the Ellipsis, or $\frac{ccxx}{tt} - cc$ in *Hyp.* And $\overline{CF}^2 = xx + cc - \frac{ccxx}{tt}$ in *Ellip.* or $xx - cc + \frac{ccxx}{tt}$ in *Hyp.* because FPC is a right-angled Triangle. Again CP (x) : Ca (t) : : Ca (t) : $CT = \frac{tt}{xx}$. And $\overline{PT}^2 = xx - 2tt + \frac{t^4}{xx}$, and $\overline{FT}^2 = xx + cc - 2tt + \frac{t^4}{xx}$, $- \frac{ccxx}{tt}$ in *Ellip.* or $xx - cc - 2tt + \frac{t^4}{xx} + \frac{ccxx}{tt}$ in *Hyp.* because FPT is a right-angled Triangle. Now, the Triangles FPT, CET, are similar, because the Angles at E and P are right ones, and the Angle ETC in the *Ellip.* common, (but in the Hyperbola the Angle ETC $=$ PTF,) whence $\overline{FT}^2$ $\left(xx \mp cc - 2tt + \frac{t^4}{xx} \mp \frac{ccxx}{tt}\right)$: $\overline{EP}^2$ $\left(cc - \frac{ccxx}{tt}\right.$ or $\left.\frac{ccxx}{tt} - cc\right)$: : $\overline{CT}^2$ $\left(\frac{t^4}{xx}\right)$: $\overline{CE}^2 = \frac{t^4 c^2}{t^4 - t^2 x^2 \mp c^2 x^2}$. Farther, the Square of the Semi-Conjugate, *viz.* $\overline{CG}^2$ $(= \overline{Ca} + \overline{Cb}^2 - \overline{CF}^2$ in *Ellip.* or $= \overline{CF} + \overline{Cb}^2 - \overline{Ca}^2$ in *Hyp.*) is $= tt - xx + \frac{ccxx}{tt}$ in *Ellip.* or $xx + \frac{ccxx}{tt} - tt$ in *Hyp.* and $\overline{CE}^2 \times \overline{DF}^2$ $(= \overline{DG}^2)$ is $= \frac{\mp t^8 c^2 + t^4 c^4 x^2 \mp t^6 c^2 x^2}{t^6 \mp t^2 x^2 c^2 \mp t^4 x^4}$, which is $= \overline{Ca}^2 \times \overline{Cb}^2 = \mp ttcc$; as it evidently appears by multiplying the Denominator by $\mp ttcc$: And therefore $Ca \times Cb = CG \times CE$, and so $4 CE \times EG = 4 Cb \times Ca$. *W. W. D.*

5. *If from any Point* M *in an Equilateral Hyperbola there be drawn the Right Line* MG *parallel to the Asymptote* CN, *and the Right Line* OM *parallel to the other Asymptote* CS; *I say the Rectangle under* OM $\times$ OC *will always be equal to the Square of the Line* RQ, *which is drawn from the Point* A, *wherein the Axis* CP *cuts the Curve, parallel to the Asympto* CS, *and terminating in the other Asymptote* CN.

For draw the Ordinate MP, and raise the Perpendicular AQ, and let fall AR perpendicular to CN; now CR, RQ, RA, are equal to one another, because the Axis CP does



bisect the Angle form'd by the Asymptotes, and AQ is perpendicular to the Axis, and AR parallel to CS: Then call CN, s, CQ, m, the Semi-Axis CA, a; and the Line AQ, (which is equal to the Semi-conjugate Axis) b. The Triangles CAQ, CPN,

CPN, are similar: Therefore CQ, (m) : CN (s) : : CA (a) : CP $= \frac{as}{m}$. And CQ (m) : CN (s) : : QA (b) : NP $= \frac{bs}{m}$. But by the Nature of the Hyperbola $\overline{CA}^2$ (aa) : $\overline{AQ}^2$ (bb) : : CP + CA × AP $\left(\frac{aass}{mm} - aa\right)$: $\overline{PM}^2 = \frac{bbss}{mm} - bb$.

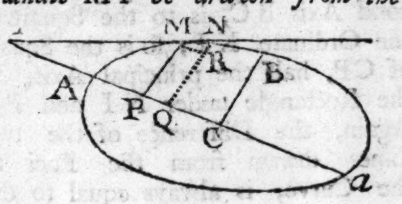
Whence,

$$MN = \frac{bs}{m} - \sqrt{\frac{bbss}{mm} - bb}.$$

† Again, the Triangles RAQ, OMN, are similar, and both Isosceles; therefore, AQ (b) : AR $\left(\frac{m}{2}\right)$: : MN $\left(\frac{bs}{m} - \sqrt{\frac{bbss}{mm} - bb}\right)$: OM or ON $= \frac{s}{2} - \sqrt{\frac{ss - mm}{4}}$. And so CO or GM $= \frac{s}{2} + \sqrt{\frac{ss - mm}{4}}$. And OC × OM $= \frac{ss}{4} - \frac{ss}{4} + \frac{mm}{4} = \frac{mm}{4}$, which is equal to $\overline{RA}^2$ or $\frac{\overline{CQ}^2}{4}$. *W. W. D.*

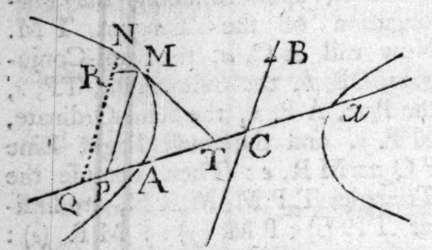
The Demonstration of this Property being easy and new, (at least to me,) was the Cause of my laying it down here.

6. *If* A a *be any Diameter of an Ellipsis, or Hyperbola,* C *the Centre, and if the Right Line* TM *touches this Ellipsis in the Point* M, *and the Ordinate* MP *be drawn from the Point of Contact to the Diameter* Aa; *I say,* CP, CA, CT *are in continual Proportion.*



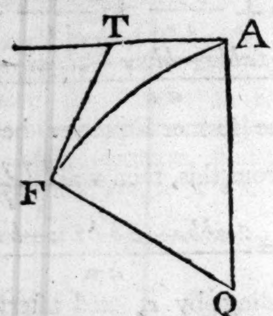
Suppose the Arch MN to be infinitely small, and draw NQ parallel to PM, and MR parallel to Aa; now the small Triangle MNR will be similar to the Triangle TPM, because the very small Arch MN may be looked upon as being the Prolongation of the Tangent TM. Now call AC, a, the Semi-Conjugate, CB, b, the Subtangent, TP, s, the Part, AP, x, the Semi-Ordinate, MP, y, and the small Right Line PQ = MR, e: Then, because the Triangles TPM, MRN, are similar TP (s) : PM (y) : : MR (e) : RN $= \frac{ey}{s}$. Then, if $\overline{QN}^2$ $\left(yy + \frac{2yye}{s} + \frac{yyee}{ss}\right)$ be put for yy in the Equation $yy = \frac{2abbx - bbxx}{aa}$ expressing the Nature of the Ellipsis; and AQ $(x + e)$ for x, we shall have $yy + \frac{2yye}{s} + \frac{yyee}{ss} = \frac{2abbx + 2abbe - bbxx - 2bbex - bbee}{aa}$, and if the former Equation be subtracted from this, then will $\frac{2yye}{s} + \frac{yyee}{ss} = \frac{2abbe - 2bbex - bbee}{aa}$, and dividing by e, and afterwards striking out all the Terms adfected with e, because they are infinitely less than the others, and then will $\frac{2yy}{s} = \frac{2abb - 2bbx}{aa} = \left(\frac{yy}{s} = \frac{abb - bbx}{aa},\right)$ and again substituting for yy, its Value $\frac{2abbx - bbxx}{aa}$, and bb will be gotten out, and then

then s will be $=\frac{2ax-xx}{a-x}$. Now, TC×PC, $\left(\frac{2ax-xx}{a-x}+\overline{a-x}\times\overline{a-x}\right.$, that is, $\left.\frac{aa}{a-x}\times a-x\right)$ is $=\overline{AC}^2$ (aa) which was the thing to be demonstrated.



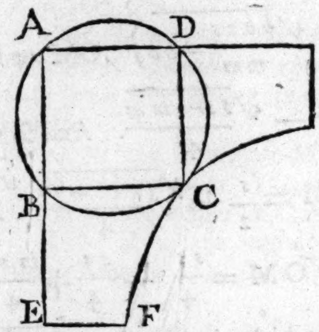
After the same manner we prove this in the *Hyperbola*, only observing here that the Equation, expressing the Nature of the same, is $yy=\frac{2abbx+bbxx}{aa}$.

7. If QFA be a Sector, contain'd under two Right Lines, meeting in the Centre Q, and the Conic Curve



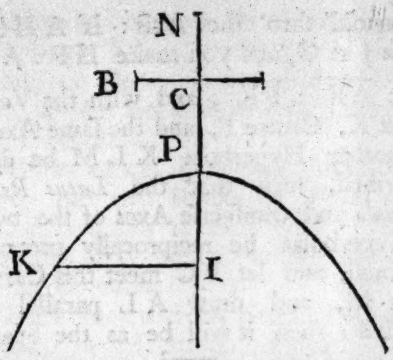
FA, the Point A being the Extremity of the Axis: And if a Tangent in F meets the Tangent in A in the Point T, and AT be call'd t; and the Rectangle under half the *Latus Rectum*, and half the *Latus Transversum*, be supposed $=1$, then shall the Sector of the *Hyperbola*, Circle or Ellipsis, divided by the *Semi-Latus Transversum* be $=\frac{t}{1}\pm\frac{t^3}{3}+\frac{t^5}{5}\pm\frac{t^7}{7}$, &c. The ambiguous Sign $\pm$ being $+$ in the *Hyperbola*, and $-$ in the Circle and Ellipsis. Whence if the Square circumscribing the Circle be $=1$, the following Series will be had, *viz.* $\frac{1}{3}+\frac{1}{8}+\frac{1}{15}+\frac{1}{24}+\frac{1}{35}+\frac{1}{48}+\frac{1}{63}+\frac{1}{80}+\frac{1}{99}+\frac{1}{120}$, &c.

8. In these Series $\frac{1}{3}+\frac{1}{35}+\frac{1}{99}$, &c. expresses the Area of the Circle ABCD, and $\frac{1}{8}+\frac{1}{48}+\frac{1}{120}$, &c. the Area of the Equilateral



Hyperbola BCEF, when BC is the double of EF, and the inscribed Square is $=\frac{1}{4}$. The Numbers 3, 8, 15, 24, being square ones lessen'd by Unity.

9. All the Properties of Diameters, Tangents, and Foci, &c. in the *Hyperbola*, are the same as those in the Ellipsis, only using Differences for Sums. As for Example, as the Square of the Semi-Conjugate, or second Axis BC, is to the Square of the Ordinate KI; so is the Square of CP, half the principal Axis, to the Rectangle under NI and PI. Again, the Difference of the two Lines drawn from the Foci to the Curve, is always equal to the prin-

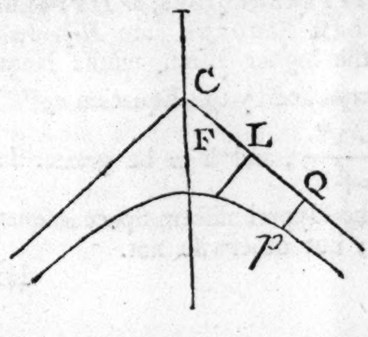


principal Axis. Also the Difference of the Squares of any two conjugate Diameters are always equal to the Difference of the Squares of the conjugate Axes.

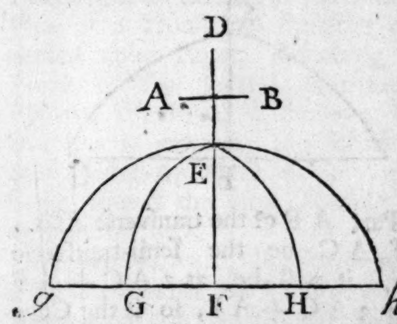
10. Any two Lines drawn in the *Hyperbola*, parallel to each other, and cut by a third, have the same Property as is mention'd of two parallel Lines drawn in the Ellipsis. See *Ellipsis*.

HYPERBOLICAL CYLINDROID, is a solid Figure, whose Generation is given by Sir *Christopher Wren*, in *Philos. Transact.* N° 48. There are two opposite *Hyperbolæ*, joined by the Transverse Axis, and thro' the Centre there is a Right Line drawn at Right Angles to that Axis, then the *Hyperbolæ* are supposed to revolve; by which Revolution a Body will be generated, which he calls an *Hyperbolic Cylindroid*; and whose Bases, and all Sections parallel to them, will be Circles. And in N° 53. of the *Transactions*, he applies it to the Grinding of hyperbolical Glasses; and he says, they must be either formed this way, or not at all.

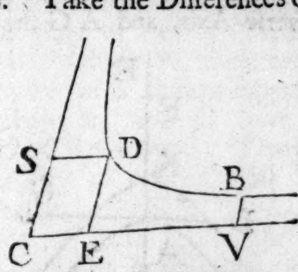
HYPERBOLIC SPACE, is the Area or Space contained between the Curve of the Hyperbola and the whole Ordinate. If $CL = b$, and $LQ = x$, and $CF = a$, and $QP = y$, then $a^2 = by + xy$; and if $a = b = 1$, the Space between the Asymptotes will be expressed by $x - \frac{1}{2}x^2 + \frac{1}{3}x^3 + \frac{1}{4}x^4 + \frac{1}{5}x^5$, &c.



Any Hyperbolic Space GEHG, is to any other Hyperbolick Figure of the same Height *g* E *h g*, (whose *Latus Rectum* and *Transversum*, as in the Circle, are equal; and also both equal to DE, the *Latus Transversum* of the former Space) : : as the Conjugate Axis AB : is to the *Latus Transversum* DE.



The Area of any asymptotical hyperbolic Space DEVB, may be thus found by means of the Logarithms. Take the Differences of the

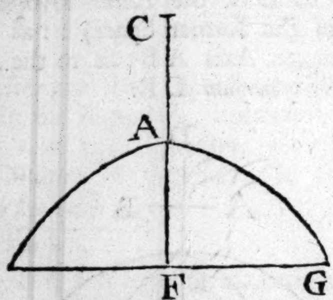


Logarithms of the Numbers expressing the Ratio of DE to BV, and find the Logarithm of that Difference; to which add the constant Logarithm 0.3622156887; and the Sum will be the Logarithm of a Number expressing the Space EDBV, in

in ſuch Parts as the Oblong C D is 10000000000.

Hyperbolicum Acutum, is a Solid made by the Revolution of the infinite Area of the Space contained between the Curve and the Aſymptote, in the *Apollonian* Hyperbola, turning round that Aſymptote. This produces a Solid or Body infinitely long; and yet, as *Torricellius* plainly demonſtrates, (who gave it this Name) it is equal to a finite Solid or Body.

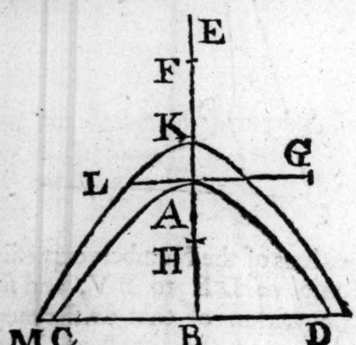
Hyperbolic Conoid, is a Solid generated by the entire Rotation of the hyperbolic Space F A G about



the Part A F of the tranſverſe Axis.

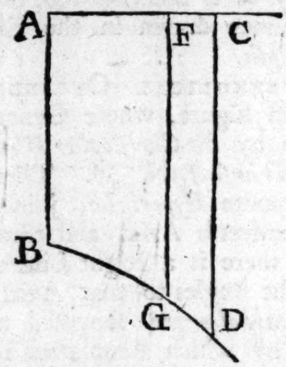
If A C be the ſemi-tranſverſe Axis, it will be, as 2 A C + A F is to 3 A C + A F, ſo is the Cone whoſe Baſe is the Circle deſcribed by F G, and Altitude A F, to the Conoid deſcribed as above.

If F be the Centre, A E the Tranſverſe Axis, and A G the *Latus*



Rectum of the Hyperbola C A D being the Section of an Hyperbolic Conoid thro' the Axis: If A H be $= \frac{1}{2}$ A G, and you make H F : A F : : $\overline{AF}^2 : \overline{FK}^2$, and with the Vertex K, Centre F, and the ſame Axis, another Hyperbola K L M be deſcribed, ſuch that the *Latus Rectum's* and tranſverſe Axes of the two Hyperbolas be reciprocally proportional, and let B C meet this Curve in M, and draw A L parallel to M B; then it will be as the Space A L M B is to $\frac{1}{2}\overline{BC}^2$, ſo is the Curve Surface of the Hyperbolic Conoid to its Circular Baſe.

A Cylinder equal to the Solid gerated by the Rotation of the hyperbolical Space A F G B about the Semi-Conjugate Axis A C, may be found thus: Let P be a third Proportional



to A C and A F; then a Cylinder the Radius of whoſe Baſe is F G, and Altitude a fourth Proportional to A C + P, A C + $\frac{1}{3}$ P, and AF, will be equal to the Solid deſcribed, as above; and the curve Superficies of the ſaid Solid may be had by the Quadrature of the hyperbolic Space.

Hyperboloides, *or* Hyperboliform Figures, are *Hyperbola's* of the higher Kind, whoſe Nature is expreſſed by this Equation $ay^{m+n} = \frac{bx^m}{a+n^n}$, and if m be greater than n, the Hyperboliform Space is ſquarable; but otherwiſe not.

Hyperthyron, in Architecture, is a large Table, usually placed over Gates or Doors of the *Dorick* Order, above the *Chambranle*, in form of a Frize.

Hypethre, in ancient Architecture, was two Ranks of Pillars all about, and ten at each Face of any Temple, *&c.* with a Peristyle within of six Columns.

Hypomochlion, Fulcrum, *or* **Prop**, in Mechanics, signifies the Roller, which is usually set under the Leaver, or under Stones or Pieces of Timber, to the end that they may be more easily lifted up, or removed.

Hypothenuse in a right-angled Triangle, is that Side which subtends the right Angle.

In all rignt-angled Triangles, the Figure described upon the Hypothenuse as a Side, is equal to the Sum of the two Figures described upon the other two Sides of that Triangle, being all three similar.

Hypothesis, is the same with Supposition; or it is a Supposition of that which is not, for that which may be; and it matters not whether what is supposed to be true, be so or not; but it must be possible, and should always be probable.

Dr. *Barrow* says, Hypotheses, or Postulatums, are Propositions assuming or affirming some evidently possible Mode, Action, or Motion of a Thing, and that there is the same Affinity between Hypotheses and Problems, as between Axioms and Theorems. A Problem shewing the Manner, and demonstrating the Possibility of some Structure, and an Hypothesis assuming some Construction which is manifestly possible.

Hypotrachelion, in Architecture, is the Top or Neck of a Pillar, or the most slender Part of it, which toucheth the Capital. It is taken by some for that Part of the *Tuscan* or *Dorick* Capital, which lies between the *Echinus* and the *Astragal*; and is otherwise call'd the *Callar*, *Gorge*, or *Frize of the Chapiter*.

I.

Jacob's-Staff, a Mathematical Instrument for taking Heights and Distances. The same with *Cross-Staff*.

Ichnography, in Perspective, is the View of any thing cut off by a Plane parallel to the Horizon, just at the Base or Bottom of it. And in Architecture, is taken for the Geometrical Plane or Platform of an Edifice, or the Ground-Plot of a House or Building delineated upon Paper, describing the Form of the several Apartments, Rooms, Windows, Chimneys, *&c.* and this is properly the Work of the Master-Architect or Surveyor, being indeed the most abstruse and difficult of any.

Ichnography, in Fortification, is, in like manner, the Plane or Representation of the Length and Breadth of a Fortress; the distinct Parts of which are marked either upon the Ground itself, or upon Paper.

Icosahedron, is a regular Body, consisting of twenty Triangular Pyramids, whose Vertexes meet in the Centre of a Sphere supposed to circumscribe it, and so have their Height and Bases equal: Therefore, the Solidity of one of those Pyramids being multiplied by 20, the Number of Bases gives the solid Content of the *Icosahedron*.

Ides *of a Month*, among the *Romans*, were the Days after the Nones were out. They commonly fell out on the 13th of every Month, except in *March*, *May*, *July*, and *October*, (which they call the *Full Months*,

as all the others were called *Hollow*,) for then they were on the 15th, because in those Months the Nones were on the 7th.

JET D'EAU, is the *French* Word for a Pipe of a Fountain, which casts up the Water into the Air.

M. *Mariotte*, in his Treatise *Du Mouvement des Eaux*, &c. saith, That a *Jet d'Eau* will never rise so high as its Reservatory, but always falls short of it by a Space, which is in a subduplicate Ratio of that Height; and this he proves by several Experiments.

He saith also, That if a greater branches out in smaller ones, distributed to different Jets, the Square of the Diameter of the main Pipe must be proportioned to the Sum of all the Expences of its Branches. And particularly he saith, That if the Reservatory be 52 Foot high, and the Adjutage half an Inch in Diameter, the Pipe ought to be three Inches in Diameter.

IGNIS-FATUUS, is a certain Meteor that appears chiefly in the Summer Nights, for the most part frequenting Church-Yards, Meadows, and Bogs, as consisting of a somewhat viscous Substance, or a fat Exhalation; which being kindled in the Air, reflects a kind of thin Flame in the Dark, yet without any sensible Heat, often flying about Rivers, Hedges, *&c.* because it meets with a Flux of Air in those Places. This Meteor is well known among the common People under the Name of *Will-of-the-Whisp*, or *Jack-with-a-Lanthorn*.

ILLUMINATIVE MONTH, is that Space of the Time that the Moon is visible, betwixt one Conjunction and another.

IMAGE, in Optics, is the Appearance of an Object, by Reflexion or Refraction.

In all Plane Speculums the Image appears of the same Magnitude as the Object, and as far behind the Speculum, as the Object is distant before it.

In Convex Speculums, the Image is farther distant from the Centre of the Convexity, than from the Point of Reflexion, and the Image appears less than the Object.

IMAGINARY ROOT of an Equation, are those Roots or Values of the unknown Quantity in an Equation, which are wholly or partly express'd by the Square Root of a negative Quantity, and of which in every Equation their Number is always even. As $+\sqrt{-aa}$, and $-\sqrt{-aa}$ are the Roots of the Equation $xx+aa=0$. So also $\frac{a}{2}-\sqrt{-\frac{3}{4}aa}$, and $-\frac{a}{2}-\sqrt{-\frac{3}{4}aa}$ are the two Imaginary Roots of the Equation $xx+ax+aa=0$.

The Imaginary Roots of Equations may be found by the following Rule: Constitute a Series of Fractions, whose Denominators are the Numbers in this Progression 1, 2, 3, 4, 5, *&c.* going on so far as the Number expressing the Dimension of the Equation, and Numerators the same Series of Numbers in a contrary Order; and divide each of these Fractions by that next before it, and place the Fractions arising over the intermediate Terms of the Equation; then under each of the intermediate Terms, if its Square multiplied by the Fraction over it, be greater than the Product of the Terms on each side it, place the Sign $+$, but if not, the Sign $-$; and under the first and last Term place the Sign $+$. Then will that Equation have so many imaginary Roots, as there are Mutations of the under-written Signs from $+$ to $-$, and $-$ to $+$. And when there are two or more Terms wanting at the same time, the Sign $-$ is to be placed

placed under the first of the deficient Terms, the Sign + under the second, the Sign — under the third, and so on, varying the Signs, excepting that under the last of the deficient Terms, the Sign + must be always put when the two nearest Terms on each side the deficient Terms have contrary Signs.

Sir *Isaac Newton* was the first who gave a general Rule to find the imaginary Roots of an Equation, which he has done in his *Algebra*, and indeed is the very same with this here laid down. But as he himself observes, it will sometimes fail of discovering all such Roots, for some Equations may have more imaginary Roots than can be found by this Rule, tho' this seldom happens. He has not subjoined the Demonstration which very easily follows from his Rule for finding the Unciæ of the several Powers of a binomial Root; for when the Roots of any Equation are all equal, and m be the Dimension, the Unciæ (or Numbers prefix'd) to the first Term will be 1; to the second $\frac{m-0}{1}$; to the third $\frac{m-0}{1} \times \frac{m-1}{2}$; to the fourth $\frac{m-0}{1} \times \frac{m-1}{2} \times \frac{m-2}{3}$; to the fifth $\frac{m-0}{1} \times \frac{m-2}{3} \times \frac{m-3}{4}$; and so on; and the Square of the second Term will be to the Product of the 1st and 3d as $\frac{m-0}{1}$ to $\frac{m-1}{2}$; the Square of the third Term to the Product of the second and fourth, as $\frac{m-1}{2}$ to $\frac{m-2}{3}$; the Square of the fourth to the Product of the 3d and 5th, as $\frac{m-2}{3}$ to $\frac{m-3}{4}$; the Square of the 5th to the Product of the 4th and 6th, as $\frac{m-3}{4}$ to $\frac{m-4}{5}$; and so on: so that from hence is gain'd the Fraction which he directs you to put over the several Terms of the Equation; and the Reason of the following Part of his Rule chiefly follows from the Supposition that the Roots of any Equation, when real and unequal, must become equal before they can be imaginary: or contrariwise, if imaginary, must become equal before they can be real, upon the augmenting the unknown Quantity.

The very ingenious Mr. *Mac-Laurin* in the *Philosoph. Transactions*, has given a Demonstration of this Rule of Sir *Isaac*, together with one of his own, that will never fail. So also has the learned Mr. *Campbell*; both from very laborious and perplexing Computations: I had almost said too long and hard for one of a moderate Patience and Capacity ever to examine and be convinced of their Truth.

The real Roots of all Equations (having imaginary ones) may be easily found from common Algebra; that is, from the following Theorem, *viz.* the Sum of the Squares of any Number n of unequal Quantities, will be greater than the Sum of all the possible Varieties of all the Products of the several Quantities taken two and two, multiplied by $\frac{2}{n-1}$; which Theorem follows from this, that the Sum of the Square of two unequal Quantities is greater than twice their Product. And this last from this, That if four Quantities are proportional, the Sum of the greatest and least is always greater than the Sum of the two others.

The real and imaginary Roots of Equations may be found alſo from the Method of Fluxions, apply'd to the Doctrine of *Maximums* and *Minimums*; that is, to find ſuch a Value of x in an Equation, expreſſing the Nature of a Curve, made equal to y, an Ordinate which correſponds to the greateſt and leaſt Ordinate. But when the Equation is above three Dimenſions, the Computation will be intolerably laborious. See Mr. *Sterling*'s Treatiſe of the Lines of the Third Order.

The chief Uſe (that I know) of this Invention of imaginary Roots, is to diſcover the various Figures and Species of Curve-Lines.

Immense, is that whoſe Amplitude or Extenſion no finite Meaſure whatſoever, or how oft ſoever repeated, can equal.

Immersion, is the plunging of any thing under Water. 'Tis alſo uſed by Aſtronomers, to ſignify that any Planet is beginning to come within the Shadow of another; as in Eclipſes, whenever the Shadow of the eclipſed Body begins to fall on the Body eclipſed, we ſay, that is the Time of Immerſion; and when it goes out of the Shadow, is the Time of Emerſion.

Impenetrability, is the Diſtinction of one extended Subſtance from another, by which the Extenſion of one Thing is different from that of another; ſo that two Things extended, cannot be in the ſame Place, but muſt of neceſſity exclude each other.

Imperfect Concord. See *Concords*.

Imperfect Numbers, are ſuch whoſe aliquot Parts taken all together, do either exceed, or fall ſhort of that whole Number of which they are Parts; and theſe are two ſorts, either abundant or deficient. Which ſee.

Imperial-Table, is an Inſtrument made of Braſs with a Box and Needle and Staff, uſed to meaſure Land.

Impervious. Bodies are ſaid to be impervious to others, when they will neither admit the Rays of Light, &c. nor the Effluvia of other Bodies do paſs thro' them.

Impost, in Architecture, is a Plinth, or little Cornice, that crowns a Piedroit or Pier, and ſupports the Couſſinet, which is the firſt Stone that a Vault or Arch commences.

Improper Fractions, are ſuch as have their Numerators equal to, or greater than their Denominators, as $\frac{6}{6}$, $\frac{18}{12}$, &c. Which are not Fractions properly ſpeaking, but either whole or mix'd Numbers; and are only in the form of Fractions, in order to be added, ſubſtracted, multiplied, or divided, &c.

Inaccessible Height, or Distance, is that which cannot be meaſured, by reaſon of ſome Impediment in the way; as Water, &c.

Inceptive *of Magnitude*, is a word uſed by Dr. *Wallis*, expreſſing ſuch Moments or firſt Principles, as tho' of no Magnitude themſelves, yet are capable of producing ſuch.

Thus a Point hath no Magnitude itſelf, but is inceptive of it. A Line conſider'd one way, hath no Magnitude as to Breadth, but is capable by its Motion of producing a Surface which hath Breadth, &c.

Incidence Point, in Optics, is that Point in which a Ray of Light is ſuppoſed to fall on a Piece of Glaſs.

Incident Ray, in Catoptrics and Dioptrics. See *Ray of Incidence*.

Inclination, is a word frequently uſed by Mathematicians, and ſignifies the mutual Approach, Tendence, or Leaning of two Lines, or two Planes, towards each other, ſo as to make an Angle.

The

The Inclination of two Planes is the acute Angle made by two Lines drawn one in each Plane, and perpendicular to their common Section.

INCLINATION *of the Axis of the Earth*, is the Angle which it makes with the Plane of the Ecliptic, or the Angle between the Planes of the Equator and Ecliptic.

INCLINATION *of Meridians*, in Dialling, is the Angle that that Hour-Line on the Globe, which is perpendicular to the Dial-Plane, makes with the Meridian.

INCLINATION *of a Plane*, in Dialling, is the Arch of a vertical Circle, perpendicular to both the Plane and the Horizon, and intercepted between them.

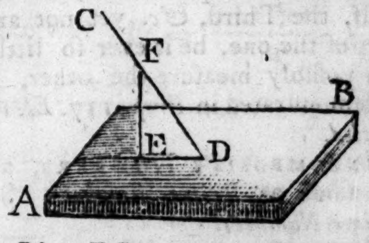
INCLINATION *of the Planes of the Orbits of the Planets to the Plane of the Ecliptic*, are thus: *Saturn*'s Orbit makes an Angle of two Degrees thirty Minutes, *Jupiter*'s one Degree and one Third, *Mars*'s is a little leſs than two Degrees, *Venus*'s is three Degrees and one Third, and *Mercury*'s is almoſt ſeven Degrees.

The Inclination of the Orbit of a Planet may be found by having its Latitude and Diſtance from the Node given; for the Latitude is one Side of a right-angled ſpherical Triangle; the Diſtance from the Node, the other Side; and the Angle oppoſite to the Latitude, the Inclination of the Orbit.

INCLINATION *of a Planet*, is an Arch of the Circle of Inclination, comprehended between the Ecliptic and the Place of a Planet in his Orbit.

INCLINATION *of a Ray*, in Dioptrics, is the Angle which this Ray makes with the Axis of Incidence, in the firſt Medium, at the Point where it meets the ſecond Medium.

INCLINATION *of a right Line to a Plane*, is the acute Angle which this right Line makes with another right Line drawn in the Plane through the Point, where it is alſo cut by a Perpendicular drawn from any Point of the inclined Line. As the Line CD inclines to the Plane AB, and the Inclination thereof is meaſur'd by the Angle EDC, made by the inclin'd Line CD, and

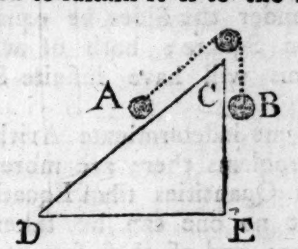


the Line ED drawn in the Plane from the Point D, through the Point E, where a Perpendicular let fall from any Point F, in the inclined Line to the Plane, cuts it.

INCLINING DECLINING DIALS. See *Declining Inclining Dials.*

INCLINING DIRECT SOUTH, or NORTH DIALS. See *Direct South or North Inclining Dials.*

INCLINED PLANE, is that which makes an oblique Angle with the Horizon. Any Body, as A, laid upon an inclin'd Plane, loſes Part of its Weight, and the Weight B required to ſuſtain it is to the Weight



of A, as the Height EC of the Plane to the Length DC of it. And from hence it follows that the Inclination of the Plane may be ſo little, that the greateſt Weight may be ſuſtain'd on it by the leaſt Power.

INCOMMENSURABLE NUMBERS, are ſuch as have no common Diviſor,

for, that will divide them both equally, as 3 and 5.

INCOMMENSURABLE QUANTITIES, are those which have no aliquot Part, or any common Measure that may measure them; as the Diagonal, and Side of a Square: for altho' that each of those Lines have infinite aliquot Parts, as the Half, the Third, *&c.* yet not any Part of the one, be it ever so little, can possibly measure the other, as is demonstrated in *Prop.* 117. *El.* 10. *Euclid.*

INCOMPOSITE NUMBERS, are the same as *Prime Numbers.* See *Prime Numbers.*

INCREMENT, or DECREMENT, is the Increase or Decrease of a Quantity. There is a learned *Latin* Treatise of the Doctrine of *Increments*, published by *Brooke Taylor*, F. R. S. See more of this under *Series.*

INCURVATION *of the Rays of Light.* See *Light* and *Refraction.*

INDETERMINED PROBLEM, is that which is capable of an infinite Number of Answers: As to find two Numbers, whose Sum, together with their Product, shall be equal to a given Number, or to make a Rhomboides such, that the Rectangle under the Sides be equal to a given Square; both of which Problems will have infinite Solutions.

In some indeterminate Arithmetical Problems there are more unknown Quantities than Equations, and yet no one can be taken at pleasure; and of these sort are all Problems, in which the Quantities are to be equal to Squares or Cubes. In these Problems other Quantities must be taken at pleasure, and from these are determined the Quantities of the indeterminate Problems; and when a Quantity, whose Conditions are determined, must be made equal to a Square or Cube, the whole Artifice consists in this, that the Quantity to be made equal to a Square be algebraically expressed, and put equal to a Square; and in such manner that the Equation thereby may be reduced to one Dimension with respect to the unknown Quantity of the Problem.

Some sort of these Problems may be solved by an universal way of Solution, altho' different from that of determinate Problems; and others again are to be come at particularly from a good Skill in the Properties of Numbers.

1. If xx and yy be two Square Numbers to be found, whose Difference a is given, it will be $a = xx - yy$; and $a + yy = xx$; so that $a + yy$ must be a Square. Take u (at pleasure) $= x + y$; then will $x = \frac{uu + a}{2u}$.

2. If xx and yy are two Square Numbers to be found, whose Sum aa is given; then must $aa - yy$ be a square Number, and taking u at pleasure, let $x + a$ be $= uy$; then will $x = \frac{auu - a}{uu + 1}$.

3. If aa, bb two given square Numbers be to be resolved into two other square Numbers xx and yy, it will be $aa + bb = xx + yy$; and so $aa + bb - yy$ must be a Square Number. Put $y = z - b$, and $x = uz - a$, then will $\frac{2b + 2au}{uu + 1} = z$, $y = \frac{b + 2au - buu}{uu + 1}$, and $x = \frac{2bu + auu - a}{uu + 1}$.

4. There are many other Problems of this sort; such as to find two Numbers, whereof if to one you add the Square of the other, the Sum will be a square Number.— To find three Numbers whose Sum is

is a Square, and two added together shall make a Square.—To find three square Numbers in an Arithmetical Progression, with an infinite Variety of others, which any one of himself may easier propose than solve.

The following two Problems, *viz.* to find a Cube Number which added to all its aliquot Parts shall make a square Number: And to find a square Number, which added to all its aliquot Parts shall make a Cube, were formerly proposed by Monsieur *Fermat*, as a Challenge to all the Mathematicians of *Europe*; the former of which Dr. *Wallis* at first very oddly answered, *viz.* by saying that 1 was such a Number; for, says the Doctor, 1 is a Cube Number, which added to all its aliquot Parts being none, makes the square Number 1. But this was taken by the *French* as a shuffling Answer unworthy such a Man as the Doctor, and indeed I think so too; for it is talking idlely, to speak of adding a Number to its aliquot Parts, when it has no aliquot Parts. But afterwards the Doctor gave many Answers to those Problems, as well as some others of a difficult Nature. See the *Letters* that passed between Dr. *Wallis*, the Lord *Bronker*, Sir *Kenelme Digby*, &c. to be seen in the Doctor's Works.

If it be required to find what Number of Guineas and Pistoles will make one hundred Pounds:

Put x for the Pistoles, and y for the Guineas; then will $17x + 21y$ be $= 2000$, and so $x = \frac{2000 - 21y}{17}$. Now this must be a whole Number, in order to which find the nearest Number to 2000. But less, that 17 will divide without a Remainder, which is easily done by dividing 2000 by 17, and then multiplying the Quotient by 17, the Number will be 1989; then will 17 divide $-17y + 1989$ without a Remainder; and since it must also divide $2000 - 21y$ without a Remainder, it must also divide the Difference of these two last Expressions, *viz.* $-17y + 1989$ and $2000 - 21y$, which Difference is $4y - 11$. Let $\frac{4y - 11}{17}$ be $= n$, then will y be $= \frac{17n + 11}{4}$; so that $\frac{17n + 11}{4}$ must be a whole Number. But $16n + 12$ is divisible by 4; therefore the Difference $\frac{n - 1}{4}$ of $\frac{17n + 11}{4}$, and $\frac{16n + 12}{4}$ must be a whole Number: So that n may be 1, 5, 9, 13, 17, &c. And accordingly y will be $= \frac{1 \times 17 + 11}{4} = 7$, or $\frac{5 \times 17 + 11}{4} = 24$, or $\frac{9 \times 17 + 11}{4} = 41$, or $\frac{13 \times 17 + 11}{4} = 58$, or $\frac{17 \times 17 + 11}{4} = 75$, or $\frac{21 \times 17 \times 11}{4} = 94$; that is, if to 7 you add successively 17, you will have five of the Values of y; for $7 + 17$ is $= 24$. $24 + 17$ is $= 41$. $41 + 17$ is $= 58$. $58 + 17$ is $= 75$, and $75 + 17$ is $= 94$; then the correspondent Number of Pistoles will be 109, 88, 67, 46, 25, and 4.

The Writers upon determinate Problems, are *Diophantus*, *Kersey*, *Prestet*, *Ozanam*, *Kirkby*, &c.

INDEX, *Characteristic*, or *Exponent of a Logarithm*, is that which shews of how many Places the absolute Number belonging to the Logarithm doth consist, and of what nature it is, whether Integer or a Fraction. Thus, in this Logarithm 2.523421, the Number standing on the

the Left-hand of the Point is called the *Index*; and because it is 2, shews you that the absolute Number answering to it, consists of three Places; for 'tis always one more than the Index. If the absolute Number be a Fraction, then the Index of the Logarithm hath a negative Sign, and is marked thus, $\bar{2}.523421$.

INDEX *of a Quantity*, is that Quantity shewing to what Power it is to be involved; as a^3 shews that a is to be involved to the third Power; where 3 is the Index, and $\overline{a+b}^{n+1}$, shews that $a+b$ is to be raised to the Power $n+1$, where $n+1$ is the Index.

If a Series of Geometrical Progressionals be in this Order, $1.x.xx.x^3.x^4.x^5.x^6.x^7$, &c. Their Indexes or Exponents will be in Arithmetical Progression, and stand thus, 0, 1. 2. 3. 4. 5. 6. 7. But if they are Fractions, as

$\frac{1}{x}\ \frac{1}{x^2}\ \frac{1}{x^3}\ \frac{1}{x^4}\ \frac{1}{x^5}\ \frac{1}{x^6}\ \frac{1}{x^7}$; then their Exponents will be Negative, and stand thus,

$-1. -2. -3. -4. -5. -6. -7.$

For if you suppose $x=2$, then will $\frac{1}{x}=1$, and $\frac{1}{xx}=\frac{1}{4}$, and $\frac{1}{x^3}=\frac{1}{8}$, &c.

Or if you express the Geometrical Series by means of the Exponents, it will stand thus, x^{-1}, x^{-2}, &c. And if it were expressed thus x^0, then it will be $x^0=1$; because 2 is the Denominator of the Ratio, in which Unity is not affected. Thus also $\frac{1}{x^4}=x^{-4}$, and $\frac{1}{x^3}=x^{-3}$, and $1=x^0$, $x^1=x$, $x^2=xx$, &c.

Also the Exponent of $\sqrt{x}$ will be $\frac{1}{2}$, because as $\sqrt{x}$ is a mean Proportional between 1 and x, so $\frac{1}{2}$ is an Arithmetical Mean between 0 and 1.

And the Exponent of $\sqrt[3]{x}$ will be $\frac{1}{3}$, because as $\sqrt[3]{x}$ is the first of the two mean Proportionals between 1 and x; so $\frac{1}{3}$ is the first of the two Arithmetical Means between 0 and 1.

For since $1.\ \overset{2}{x}.\ \overset{4}{xx}.\ \overset{8}{xxx}.$ are continually proportional, therefore their Cubes, or any other Roots, will be also continually proportional; that is, $\sqrt{}^3 : x\ (=1.)\ \sqrt[3]{x}.\ \sqrt[3]{xxx}\ (=x) \div$.

So also, $1.\ x.\ xx.\ x^3.\ x^4.\ x^5. \div$: Wherefore the Roots of the 5th Power of those Quantities will be $\div$: That is, $\sqrt[5]{1}.\ \sqrt[5]{x}.\ \sqrt[5]{x^2}.\ \sqrt[5]{x^3}.\ \sqrt[5]{x^4}.\ \sqrt[5]{x^5}.\ (=x.)$

Also for the same Reason, the Exponent of $\sqrt[5]{x^4}$, will be $\frac{4}{5}$.

N. B. Always place the Index of the Letter (or Power) over that of the Radical Sign.

Thus in Fractions, the Exponent of $\frac{1}{x}$ will be -1, of $\frac{1}{\sqrt{x^3}}$ will be $-\frac{3}{2}$, of $\frac{1}{\sqrt[3]{x^5}}$ will be $-\frac{5}{3}$ of $\frac{1}{\sqrt{x^7}}$ will be $-\frac{7}{2}$, &c.

N. B. $\sqrt{x}$, and $x^{\frac{1}{2}}$, or $\sqrt[3]{x}$ and $x^{\frac{1}{3}}$, or $\sqrt[5]{x^4}$, and $x^{\frac{4}{5}}$, are only two different ways of Notation for one and the same thing; the former in the old, the latter in the new way.

So likewise $\frac{1}{x^2}$ and x^{-2} are all one; and $\frac{1}{x^3}$ is x^{-3}, &c.

The

The way of reading or expreſſing Quantities ſo denoted, is thus, x^{-3} is Unity divided by the Cube of x, and if it were $x^{-\frac{7}{3}}$, it muſt be read, Unity or One divided by the Cube-Root of the 7th Power of x.

Note alſo, That the Sum of the Exponents of any two Numbers or Quantities, in any Geometric Progreſſion, makes the Exponent of the Product of thoſe two Terms.

Thus, $x^{\frac{1}{2}+\frac{1}{3}}$, or $x^{\frac{5}{6}}$, is the way of expreſſing the Product of $x^{\frac{1}{3}}$ into $x^{\frac{1}{2}}$, and $x^{-\frac{1}{3}+\frac{1}{5}}$, or $x^{-\frac{2}{12}}$ is the Product of $x^{-\frac{1}{3}}$ into $x^{\frac{1}{5}}$.

Alſo $x^{-\frac{1}{3}-\frac{1}{3}}$, or $x^{-\frac{2}{6}}$ is the Product of $x^{-\frac{1}{3}}$ into itſelf, or the Square of $x^{-\frac{1}{3}}$.

And the Difference between the Exponent of the Quotient ariſing by Diviſion of the greater by the leſs.

Thus $x^{\frac{1}{2}-\frac{1}{3}}$, or $x^{\frac{1}{6}}$, is the Exponent of the Quotient of $x^{\frac{1}{2}}$ by $x^{\frac{1}{3}}$, &c.

Let p repreſent the Exponent of N, any Number at pleaſure; and let $p=1$.

Then will $N^p=N^1$, $N^{p+1}=N^2$, and $N^{p+2}=N^3$, $N^{p+3}=N^4$, &c.

Or if $p=3$; then will $N^p=N^3$, and $N^{p+3}=N^5$, &c.

And negatively, $N^{-p}=N^3$, and $N^{p+3}=N^0$, &c.

Alſo, as o is an Arithmetical Mean between a poſitive and a negative Quantity equally diſtant from it; (*i. e.*) —. 6.o.6. are arithmetically proportional: So is 1 a Geometrical Mean between an affirmative and negative Power, at equal Diſtances from it: That is, N^{-p}. 1. N^p ∺.

Wherefore $1=N^{-p}\times N^p$.

And dividing all by N^p, $\frac{1}{N^p}=N^{-p}$. So that $\frac{1}{N^{2p}}$ is all one with N^{-2p}.

And to add ſome Examples of Multiplication and Diviſion in this way, $\frac{1}{x}\times\frac{1}{\sqrt[3]{x^5}}=x^{-1}\times x^{-\frac{5}{3}}=x^{-\frac{8}{3}}\times x^{-\frac{5}{3}}=x^{-\frac{8}{3}}=\frac{1}{x^{\frac{8}{3}}}=\frac{1}{\sqrt[3]{x^8}}$, &c.

And $\frac{1}{\sqrt[3]{x^5}}$ divided by $\frac{1}{x}$ will ſtand in this Notation; thus,

$$\frac{1}{x}\Big)\frac{1}{\sqrt{x^5}}\Big((=x^{-1})x^{-\frac{5}{3}}(=x^{-\frac{3}{3}})$$

$x^{-\frac{5}{3}}=(x^{-\frac{2}{3}}=\frac{1}{\sqrt[3]{xx}}$, &c.

Indiction. See *Cycle of Indiction.*

Indivisibles, in Geometry, are ſuch Elements or Principles as any Body or Figure may ultimately be reſolved into; and theſe Elements or Indiviſibles are in each peculiar Figure ſuppoſed to be infinitely ſmall.

This Method of Indiviſibles, is only the ancient Method of Exhauſtions, a little diſguiſed and contracted. It was firſt introduced by *Cavallerius*, in his *Geometria Indiviſibilium, Anno Dom.* 1635. Purſued after by *Torricellius* in his Works, printed 1644. And again, by *Cavallerius* himſelf in another Treatiſe, publiſhed in 1647 And is now allowed to be of excellent uſe in the ſhortening of Mathematical Inveſtigations and Demonſtrations.

Infinite, or Infinitely Great

Great Quantity, is that which has no Bounds, Ends, or Limits.

Infinitely Small Quantity, is that which is so very small, as to be incomparable to any finite Quantity, or which is less than any assignable Quantity.

1. No infinite Quantity can be augmented or lessen'd, by adding or taking from it a finite Quantity: Neither can a finite Quantity be augmented or lessen'd, by adding or taking from it an infinitely small Quantity.

2. If there be four Proportionals, and the first is infinitely greater than the second; then the third will be infinitely greater than the fourth.

3. If a finite Quantity be divided by an infinitely small one, the Quotient will be an infinitely great one; and if a finite Quantity be multiplied by an infinitely small one, the Product will be an infinitely small one.

But if by an infinitely great one, the Product will be a finite Quantity.

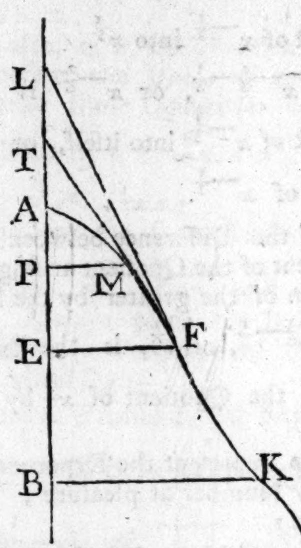
If an infinitely small Quantity be multiplied or drawn into an infinitely great one, the Product will be a finite one.

Infinite Series. See *Series*.

Inflection, in Opticks, is a multiplicate Refraction of the Rays of Light, caused by the unequal Density of any Medium, whereby the Motion or Progress of the Ray is hinder'd from going on in a right Line, and is inflected or deflected by a Curve, saith the ingenious Dr. *Hook*, pag. 217. who first took notice of this Property in his *Micrography*. And this, he saith, differs both from Reflection and Refraction, which are both made at the Superficies of the Body, but this in the middle of it within.

Sir *Isaac Newton* discovered also by plain Experiments, this Inflection of the Rays of Light, and Mr. *de la Hire* saith, he found that the Beams of the Stars being observed in a deep Valley, to pass near the Brow of an Hill, are always more refracted than if there were no such Hill, or the Observations were made on the top thereof, as if the Rays of Light were bent down into a Curve, by passing near the Surface of the Mountain.

Inflection-Point *of any Curve*, in Geometry, signifies the Point or Place where the Curve begins to bend back again a contrary way. When a Curve Line, as AFK, is partly Concave and partly



Convex towards the right Line A B, or towards a fix'd Point, then the Point F, that divides the Concave from the Convex Part, and so is at the Beginning of one, or the End of the other, is called the *Inflection Point*, or *Point of Inflection*, as long as the Curve being continu'd towards F, keeps its Course the same. But the Point K is called the *Point of Retrogression*, where it begins to reflect back again towards that Part or Side where it took its Original.

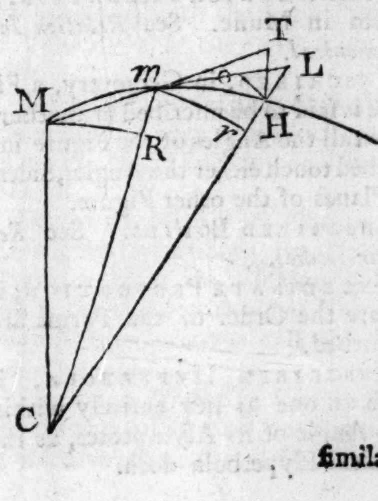
1. If

1. If thro' the Point F be drawn the Ordinate EF, as alſo the Tangent FL, and from any Point, as M, on the ſame ſide as AF, be drawn the Ordinate MP, as likewiſe the Tangent MT; then in thoſe Curves that have a Point of Inflection, the Abſciſs AP continually increaſes, and the Part AT of the Diameter, intercepted between the Vertex of the Diameter, and the Tangent MT, increaſes until the Point P falls into E, after which it again begins to diminiſh; whence the Line AT muſt become a *Maximum* AL, when the Point P falls in the Point E.

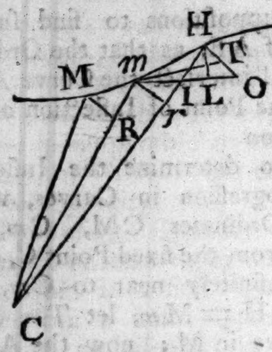
2. In thoſe Curves that have a Point of Retrogreſſion, the Part AT increaſes continually, and the Abſciſs increaſes ſo long, till the Point T falls in L; after which it again diminiſhes. Whence AP muſt become a *Maximum*, when the Point T falls in L.

3. If AE $=x$, EF $=y$, then will AL $=\frac{y\dot x}{\dot y}-x$, whoſe Fluxion which is $\frac{\dot y^2 x-\dot y\dot x\ddot y-\dot x}{\dot y^2}$, ſuppoſing $\dot x$ conſtant, being divided by $\dot x$, the Fluxion of AL muſt become nothing, that is, $-\frac{\dot y\ddot y}{\dot y^2}=0$; ſo that multiplying by $\dot y^2$, and dividing by $-\ddot y$, $\ddot y=0$; which is a general Form for finding F the Point of Inflexion or Retrogreſſion in thoſe Curves, whoſe Ordinates are parallel to one another. For the Nature of the Curve AFK being given, the Value of $\dot y$ may be found in $\dot x$; and taking the Fluxion of this Value, and ſuppoſing $\dot x$ invariable, the Value of $\ddot y$ will be found in $\dot x$, which being put equal to nothing, or Infinity, ſerves in either of theſe Suppoſitions to find ſuch a Value of AE, as that the Ordinate EF ſhall interſect the Curve AFK in F, the Point of Inflection or Retrogreſſion.

But to determine the Inflection or Retrogreſſion in Curves, whoſe Semi-Ordinates CM, Cm, are drawn from the fixed Point C, draw CM infinitely near to Cm, and make mH $=$ Mm, let Tm touch the Curve in M; now the Angles CmT, CMm, are equal, and ſo the Angle CmH, while the Semi-Ordinates increaſe, does decreaſe, if the Curve is Concave towards the Centre C, and increaſes if the Convexity turns towards it. Whence this Angle, or which is the ſame, its Meaſure will be a *Minimum* or *Maximum*, if the Curve has a Point of Inflection or Retrogreſſion; and ſo may be found, if the Arch TH, or Fluxion of it, be made equal to o, or Infinity. And in order to find the Arch TH, draw mL, ſo that the Angle TmL be equal to mCL; then if C$m=y$, $mr=x$, mT $=\dot t$, we ſhall have $y:\dot x::\dot t:\frac{\dot t\dot x}{y}$. Again draw the Arch HO to the Radius CH; then the ſmall right Lines mr, OH, are parallel; and ſo the Triangles oLH, mLr, are



ſimilar;



similar; but because HI is also perpendicular to mL, the Triangles LHI, mLr, are also similar: Whence $\dot{t} : \dot{x} :: \ddot{y} : \frac{\dot{x}\ddot{y}}{\dot{t}}$; that is, the Quantities mT, mL, are equal; But HL is the Fluxion of Hr, which is the Distance of C$m = y$: But HL is a negative Quantity, because while the Ordinate CM increases, their Difference rH decreases; whence $\dot{x}\dot{x} + \dot{y}\dot{y} - y\ddot{y} = o$, which is a general Equation for finding the Point of Inflection or Retrogression.

INFORMED STARS, are such of the fixed Stars, as are not cast into, or ranged under any Form. See *Sporades*.

INGRESS, in Astronomy, signifies the Sun's entring the first Scruple of one of the four Cardinal Signs, especially *Aries*.

INHARMONICAL RELATION, a Term in Music. See *Relation Inharmonical*.

INSCRIBED, in Geometry, a Figure is said to be inscribed in another, when all the Angles of the Figure inscribed touch either the Angles, Sides, or Planes of the other Figure.

INSCRIBED BODIES. See *Regular Bodies*.

INORDINATE PROPORTION, is where the Order of the Terms are disturbed.

INSCRIBED HYPERBOLA, is such an one as lies entirely within the Angle of its Asymptotes, as the Conical Hyperbola doth.

INSTANT, is an infinitely small Part of Duration that takes up the time of only one Idea in our Minds, without the Succession of another, wherein we perceive no Succession at all.

No natural Effect can be produced in an Instant.

From whence follows the Reason why a Burden seems lighter to the Person carrying it in the Air, the faster he moves; and why the faster any one slides or scates upon Ice, the less liable the Ice is to break, or even bend.

INTACTÆ, are right Lines to which Curves do continually approach, and yet never meet with them. These are usually called *Asymptotes*: Which see.

INTEGERS, signifies in Arithmetic, whole Numbers, in contradistinction to Fractions.

INTENSION, in Natural Philosophy, signifies the Increase of the Power, or Energy of any Quality, such as Heat, Cold, *&c.* for of all the Qualities, they say, they are intended and remitted, that is capable of Increase and Diminution.

The Intension of all Qualities increases reciprocally, as the Squares of the Distances from the Centre of the radiating Quality decreases.

INTERCALARY DAY, is the odd Day put in or inserted in the Leap-Year.

INTERCEPTED AXIS, a Term in Conic Sections, signifying the same with *Abscissa*. Which see.

INTERCOLUMNATION, in Architecture, is the Space between two Columns, which, in the *Doric* Order, is regulated according to the Distribution of Ornaments in the Frieze; but in other Orders, according to *Vitruvius*, is of five different kinds, *viz. Picnostyle*, *Systyle*, *Eustyle*, *Diastyle*, and *Aræostyle*.

This the *Latins* express by the Word *Intercolumnium*.

Interest, is the Sum reckoned for the Lot or Forbearance of ſome principal Sum lent for (or due at) a certain time, according to ſome certain Rate; and therefore is called *Principal*, becauſe it is the Sum that procreates the Intereſt, or from which the Intereſt is reckoned, and is either Simple or Compound.

Interest Simple, is counted from the Principal only, and is eaſily computed by the ſimple or compound Golden Rule.

Interior Polygon. See *Polygon Interior*.

Interior Talus. See *Talus*.

Internal Angles. See *Angles Internal*.

Intersection, in Mathematics, ſignifies the cutting of one Line or Plane by another; thus we ſay, that the mutual Interſection of two Planes is a right Line.

Interstellar, a Word uſed by ſome Authors to expreſs thoſe Parts of the Univerſe that are without and beyond our ſolar Syſtem, and which are ſuppoſed as Planetary Syſtems moving round each fixed Star as the Centre of their Motion, as the Sun is of ours; and if it be true, as 'tis not improbable, that each fixed Star may thus be a Sun to ſome habitable Orbs that may move round it, the Interſtellar World will be infinitely the greater Part of the Univerſe.

Intertíes, in a Building, are thoſe ſmall Pieces of Timber that lie horizontally between the Sommers, or between them and the Cell or Reaſon.

Interval, in Muſic, is the Diſtance between any two Sounds, whereof one is more grave, and the other more acute. They make ſeveral Diviſions of an Interval, as firſt into Simple and Compound. The Simple Intervals are the Octave, and all that are within it, as the ſecond, third, fourth, fifth, ſixth, and ſeventh, with their Varieties. Compound ones are all thoſe that are greater than an Octave, as the ninth, tenth, eleventh, &c. with their Varieties.

An Interval is alſo divided into Juſt or True, and into Falſe. All the above-mentioned Intervals, with their Varieties, whether *Major* or *Minor*, are Juſt; but the Diminutive or Superfluous ones are all Falſe. An Interval is alſo divided into a Conſonance and Diſſonance. Which ſee.

Interval *of the Fits of eaſy Reflection, and of eaſy Tranſmiſſion of the Rays of Light*, is the Spaces between every Return of the Fit and the next Return.

Theſe Intervals Sir *Iſaac Newton* ſhews how to collect, and thence to determine whether the Rays ſhall be reflected or tranſmitted at their ſubſequent Incidence on any pellucid Medium.

Intestine *Motion of the Parts of Fluids*. Where the attracting Corpuſcles of any Fluid are elaſtic, they muſt neceſſarily produce an inteſtine Motion; and this, greater or leſſer, according to the Degrees of their Elaſticity and attractive Forces.

For two elaſtic Particles, after meeting, will fly from one another (abſtracting from the Reſiſtance of the Medium) with the ſame Degree of Velocity that they met together with.

But when, in leaping back from one another, they approach other Particles, their Velocity will be increaſed.

Inverse *Method of Fluxions*, is the Method of finding the flowing Quantity from the Fluxion given, and is the ſame with what the foreign Mathematicians call the *Calculus Integralis*.

Inverse *Method of Tangents*, is the manner of finding an Equation of a Curve, or conſtructing a Curve,

by means of a given Tangent, or any other Line, whose Determination depends upon a Tangent; as to find a Curve Line, whose Subtangent is $\frac{2yy}{a}$, or whose Subtangent is a third Proportional to $r-y$ and y; or whose Subnormal is a constant Quantity; or whose Subtangent is equal to the Semi-ordinate; or to find a curve-lin'd Space, whose indefinite Area is expressed by $\sqrt{x}$, or by $a\sqrt{aa+xx}$, &c. And the Solution of most of these Problems depend upon the inverse Method of Fluxions.

INVERSE PROPORTION, or *Proportion by Inversion*. See *Proportion*.

INVERSE RATIO, is the Assumption of the Consequent to the Antecedent, like as the Antecedent to the Consequent; as if A : B :: C : D; then by Inversion of Ratio's B : A :: D : C.

INVOLUTE FIGURES. The Curve AMM (see *Evolute Curves*) is what is called an *Involute Curved Figure*.

INVOLUTION, in Algebra, is the raising up any Quantity from its Root to any other assigned; as suppose $a+b$ were to be squared, or raised up to its second Power, they say, involve $a+b$, that is, multiply it into itself, and it will produce $aa+2\,ab+bb$.

INWARD FLANKING ANGLE, in Fortification, is made by the Courtin, and the Razant Flanking Line of Defence.

IONIC ORDER, in Architecture, is the third Order, and is a kind of Mean between the strong and delicate Orders. Its Capital is adorned with Volutes, and its Cornice with Denticules.

1. The Proportions of this Pillar, as they are taken from the famous one in the Temple of *Fortuna Virilis* at *Rome*, now the Church of *St. Mary the Ægyptian*, are these:

2. The entire Order from the Superficies of the Area to the Cornice, are twenty-two Modules, or eleven Diameters.

3. The Column with its Base and Capital, contains eighteen Modules.

4. The Entablature (*i. e.* the Architrave, Frise, and Cornice) contains four Modules.

5. The Voluta of the Capital is of an oval Form.

6. The Columns in this Order are often hollowed, and furrowed with twenty four Gutters; and sometimes 'tis done only to the third Part of the Column, reckoning from the bottom, and then that third Part hath its Gutters filled with little Rods or Battoons, all the Parts of the hollow above being left empty.

IRIS, is that fibrous Circle next to the Pupil of the Eye, distinguished with Variety of Colours. See *Uvea Membrana*.

'Tis so called from its Similitude to a Rainbow, (in *Latin*, *Iris*.)

Also those changeable Colours which sometimes appear in the Glasses of Telescopes, Microscopes, &c. are called *Ires* for the same reason; as is that coloured Spectrum, which a triangular prismatic Glass will project on a Wall, when placed (at a due Angle) in the Sun-Beams. See *Rain-Bow*.

IRRATIONAL NUMBERS. See *Surd Numbers*.

IRRATIONAL QUANTITIES. See *Rational Quantities*.

IRREGULAR BODIES, are Solids, which are not terminated by equal and like Surfaces.

IRREGULAR FORTIFICATION. See *Fortification*.

IRREGULAR LINES, or CURVES. See *Regular*.

ISAGON, in Geometry, is sometimes used for a Figure consisting of equal Angles.

ISLES,

Isles, in Architecture, are the Sides, or Wings of a Building.

Isochrone Vibrations of a Pendulum, are such as are made nearly in the same Space of Time, as all the Vibrations or Swings of the same Pendulum are; whether the Arks it describes be longer or shorter: for when it describes a shorter Ark, it moves so much the slower; and when a long one, proportionably faster.

Isochronal Line, is that in which a heavy Body is supposed to descend without any Acceleration: And Mr. *Leibnitz*, in the *Act. Erud. Lips.* for *Feb.* 1689. hath a Discourse on this Subject: In which he shews, That an heavy Body with a Degree of Velocity acquired by the Descent from any Height, may descend from the same Point by an infinite Number of Isochronal Curves, and which are all of the same Species, differing from one another only in the Magnitude of their Parameters; such as are all the Quadrato-Cubical Paraboloids, and consequently similar to one another.

He shews also there, how to find a Line, in which a heavy Body descending, shall recede uniformly from a given Point, or approach uniformly to it.

Isomeria, in Algebra, is the same with *Conversion of Equations*, (see *Equations*, N°. 1.) or of *clearing any Equation from Fractions*.

Isoperimetrical Figures, in Geometry, are such as have equal Perimeters, or Circumferences.

1. Of Isoperimetrical Regular Figures, that is the greatest that contains the greater Number of Sides, or the most Angles, and consequently a Circle is the greatest of all Figures that have the same Ambit as it has.

2. Of two Isoperimetrical Triangles, having the same Base, whereof two Sides of one are equal, and of the other unequal, that is the greater, whose two Sides are equal.

3. Of Isoperimetrical Figures, whose Sides are equal in Number, that is the greatest, which is Equilateral and Equiangular. From hence follows that common Problem of making the Hedging or Walling, that will wall in one Acre, or even any determinate Number of Acres, (which call a,) hedge or wall in any greater given Number of Acres, be it what it will. Which let be b, as likewise always a Square. In order to which, call x one Side of an Oblong, (whose Area is the Number of Acres a) then will $\frac{a}{x}$ be the other Side, and $2\frac{a}{x} + 2x$, will be the Ambit of the Oblong. Which must be equal to four times the Square Root of b, that is, $2\frac{a}{x} + 2x = 4\sqrt{b}$. Whence the Value of x will be easily had, and you may make infinite Numbers of Squares and Oblongs that have the same Ambit, and yet shall have different given Area's. See the Operation.

Let $\sqrt{b} = d$.

Then $\frac{2a + 4xx}{x} = 4d$.

And $a + 2xx = 2dx$.

Also $2xx - 2dx = -a$.

And $xx - dx = -\frac{a}{2}$.

And $xx - dx + \frac{1}{4}dd = -\frac{a}{2} + \frac{1}{4}dd$.

And $x - \frac{1}{2}d = \sqrt{-\frac{a}{2} + \frac{1}{4}dd}$.

Whence

$$x = \sqrt{-\frac{a}{2} + \frac{1}{4}dd} + \frac{1}{2}d.$$

As if one Side of the Square be 10, and one Side of an Oblong be 19, and the other 1, then will the Ambits of that Square and Oblong be equal, *viz.* each 40, and yet the Area of the Square will be 100, and of the Oblong but 19.

Isosceles Triangle. See *Triangle*.

Isthmus, in Geography, is a little Neck, or Part of Land joining a Peninsula to the Continent.

Julian Period, is a Cycle of 7980 Consecutive Years, produced by the continual Multiplication of the three Cycles, *viz.* That of the Sun of 28 Years, that of the Moon of 19 Years, and that of the Indiction of 15 Years; so that this Epocha, although but artificial or feigned, (and which was the Invention of the famous *Julius Scaliger*) is yet of very good use; in that every Year within the Period is distinguishable by a certain peculiar Character; for the Year of the Sun, Moon, and Indiction, will not be the same again, till the whole 7980 Years be revolved. *Scaliger* fixed the Beginning of this Period 764 Years before the Creation.

For the finding the Year of the *Julian* Period, you have this Rule:

Multiply the *Solar* Cycle by 4845, the *Lunar* by 4200, and the *Indiction* by 6916:

Then divide the Sum of the Products by 7980, and the Remainder of the Division (without having regard to the Quotient) shall be the Year enquired after.

Julian Year, is the old Account of the Year, instituted by *Julius Cæsar*, which to this day we use in *England*, and call it the *Old Style*, in contra-distinction to the New Account, framed by Pope *Gregory*, which is eleven Days before ours, and is called the *New Style*.

Jupiter, the Name of one of the Planets. This is the biggest of all the Planets: It is distant from the Sun at a mean Rate 5201. If the Earth's mean Distance be 1000, its Excentricity is 250. The Inclination of its Orbit is 1°. 20′. Its Periodical Time is 43332 Days, 12 Hours, and it revolves about its Axis in nine Hours 56 Minutes. The Magnitude of *Jupiter* is about 2460 Times greater than our Earth.

1. In the Year 1664, *Campani*, by help of an excellent Telescope, observ'd certain Protuberances, and Inequalities in the Surface of this Planet. As also the Shadow of his Satellites, and kept his Eye upon them till they went off the Disk.

2. In the same Year, *May* 9, two Hours, *P. M.* Mr. *Hook*, with a Telescope of twelve Foot, observed a small spot in the biggest of the three obscurer Belts of *Jupiter*; and within two Hours after, he found that the said Spot had moved from East to West above half the Length of the Diameter of *Jupiter*.

3. Mr. *Cassini* observed also, near the same time, a permanent Spot in the Disk of *Jupiter*; by whose Help he not only found that *Jupiter* turns about upon his own Axis, but also the Time of such Conversion, which he estimates to be nine Hours, and 56 Minutes: Which was also confirm'd by better Observations of a Spot in the Year 1691. The Equatorial Diameter of *Jupiter* to his Polar one, Sir *Isaac Newton* computes to be as $40\frac{1}{2}$ to $39\frac{2}{5}$.

K.

Kalendar. See *Calendar*.

Kalends. See *Calends*.

Key, in Music, is a certain Tone, whereto every Composition, whether it be long or short, ought to be fitted or designed; and this Key is said

to be either flat or sharp, not in respect of its own Nature, but with relation to the flat or sharp Third, which is joined with it.

Keys *of an Organ, Harpsicord,* or *Spinnet,* are the horizontal Rows of small Pieces of Wood, or Ivory, or both; which the Fingers strike upon to play, or cause the Instrument to sound.

Knots. There are two Sorts of Knots used at Sea: One they call a *Bowling-Knot,* because by this Knot the Bowling-Bridles are fasten'd to the Crenyles. This is very fast, and will not slip.

The other is a Wall-Knot; which is a round Knob, or Knot, made with three Strands of a Rope. This Knot serves for the Top-Sail, Sheet, and Stoppers.

The Divisions of the Log-Line are thus called. These are usually seven Fathom, or forty-two Feet asunder, but they should be fifty Feet; and then as many Knots as the Log-Line runs out in half a Minute, so many Miles doth the Ship sail in an Hour; supposing her to keep going at any equal Rate, and allowing for Yaws, Lee-Way, &c.

L.

LABEL, is a long thin Brass Ruler, with a small Sight at one end, and a Centre-Hole at the other, commonly used with a Tangent-Line on the Edge of a Circumferenter, to take Altitudes, &c.

Lacunar, in Architecture, is an arched Roof or Cieling, more especially the Planking or Flooring above the Porticoes.

Ladle, an Instrument to load great Guns with Powder. It ought to be so proportioned, that two Ladles-full may charge the Piece; therefore their Breadth must be two Diameters of the Shot, and their Length for double-fortified Cannon 2 and $\frac{1}{2}$ of the Shot; for ordinary Cannon it must not exceed 2; but for Culverins and Demi-Culverins, it may be three Diameters of the Shot, and 3 and $\frac{1}{2}$ for lesser Pieces, in order to load at twice: If you will load at once, this Length of the Ladle must be double. And observe this, that a Ladle nine Balls in Length, and two Balls in Breadth, will hold just the Weight of the Iron Shot in Powder.

Lampadias, a kind of bearded Comet, resembling a burning Lamp, being of several Shapes; for sometimes its Flame or Blaze runs tapering upwards like unto a Sword, and sometimes it is double or treble pointed.

Langrel-Shot, is a sort of Shot used at Sea. It is made of two Bars of Iron, with a Joint in the middle, by which means it can be shorten'd, and so put the better into the Gun; and at each end there is an Half-Bullet, either of Lead or Iron. When 'tis discharged, it flies out at length, and is of use to cut the Enemy's Rigging, &c.

Larboard, the Left-hand Side of a Ship, when you stand with your Face to the Head.

Larmier, a flat square Member in Architecture, which is placed on the Cornice below the Cimasium, and jets out farthest; being so called from its Use, which is to disperse the Water, and to cause it to fall at a distance from the Wall, Drop by Drop, or, as it were, by Tears: For *Larme,* in *French,* signifies a Tear. See *Corona.*

Lateral Equation, in Algebra, is the same with simple Equation, which has but one Root, and may be constructed by straight Lines only.

Lation, is the Translation or

Motion of a Body from one Place to another in a right Line; and so is much the same as *Local Motion*.

LATITUDE *of a Place*, is an Arch of the Meridian of that Place, intercepted between its Zenith and the Equator; or 'tis an Arch of the Meridian intercepted between the Pole and the Horizon; and therefore is called the *Pole's Height*.

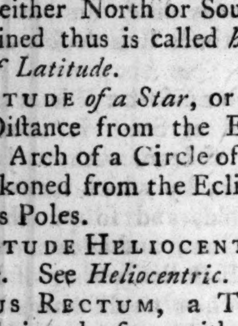
LATITUDE, in Navigation, is the Distance of a Ship from the Equinoctial, either North or South, and is counted on the Meridian; so that if a Ship sails towards the Equinoctial, she is said *to depress the Pole*; but if she sails from the Equinoctial, she is said to *raise the Pole*; and if she sails from the Equinoctial, either North or South, her Way gained thus is called *her Difference of Latitude*.

LATITUDE *of a Star*, or *Planet*, is its Distance from the Ecliptic, being an Arch of a Circle of Longitude, reckoned from the Ecliptic towards its Poles.

LATITUDE HELIOCENTRIC *of a Planet*. See *Heliocentric*.

LATUS RECTUM, a Term in Conics, being the same with the Parameter. Which see.

LATUS TRANSVERSUM *of the Hyperbola*, is a right Line lying between the Vertexes of the two opposite Sections; or that Part of the common Axis, which is between the Vertexes of the upper and lower



Cone, as the Line ED, in the following Figure.

LATUS PRIMARIUM, is a right Line belonging to a Conic Section, drawn through the Vertex of the Section of the Cone, and within it, as the Line EE or DD in the preceding Figure.

LEAP-YEAR, or BISSEXTILE, is every fourth Year; and is so called from its leaping a Day more that Year than in a common Year: For in the common Year any fixed Day of a Month changeth successively the Day of the Week. If the Year be divided by 4; and nothing remains, 'tis Leap-Year; but if 1, 2, or 3, it is so many Years after Leap-Year.

LEAVER. See *Lever*.

LEAVES, are the Notches of the Pinion of a Watch. See *Pinion*.

LEE, a Sea-Term, by which is generally meant the Part opposite to the Wind.

LEGS *of a Triangle*. When one Side of a Triangle is taken as a Base, the other two are called *Legs*.

LEMMA, is a Term used chiefly by Mathematicians, and signifies a Proposition, which serves previously to prepare the way for the more easy Apprehension of the Demonstration of some Theorem, or for the Construction of some Problem.

LENS, is a Term in Optics for a small Convex, or Plano-Convex, a Concave, or Concavo-Convex Glass.

LEO, is the fifth of the twelve Signs of the *Zodiac*, and is marked thus ♌.

LEPUS, the *Hare*, a Southern Constellation, containing thirteen Stars.

LESSER CIRCLES *of the Sphere*, are those whose Planes do not pass through the Centre of the Sphere; and which do not divide the Globe into two equal Parts, but are parallel to the greater Circles; as the Tropics and Polar Circles, and all Parallels of Declination and Altitudes;

tude; which latter being parallel to the Horizon, are called *Almicanters*.

Levant, in Geography, is properly the Eastern-side of any Continent or Country, or that on which the Sun rises; but now with our Seamen, it signifies the *Mediterranean* Sea, and especially the Eastern Part of it; and our Trade thither is called the *Levant Trade*; and a Wind that blows from thence out of the *Streights-Mouth*, is called a *Levant Wind*.

Level, is an Instrument whereby we find an horizontal Line, and continue it out at pleasure, and by this means find the true Level for conveying Water to supply Towns, make Rivers navigable, drain Bogs, *&c.* Of these Instruments there are several kinds, of which a very good one for short Distances, is this following; which consists of a round Tube of Brass or other Matter about three Foot long, and about an Inch in Diameter, bent up square at both Ends to receive two Glass-Tubes of three or four Inches, fasten'd to them. In this Tube is pour'd common or colour'd Water through one of the Ends, until there is so much as to appear in the Glass-Tubes. This Instrument being set upon a three-legged Staff, is fit for Use.

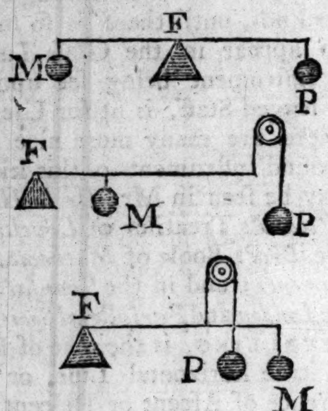
There are many more nice and compound Instruments of this kind; as may be seen in Mr. *De la Hire*'s and *Picard*'s Treatises of *Levelling*; in Mr. *Bion*'s Book of *Mathematical Instruments*; and in the *Transactions* of the *London* and *Paris Royal Societies*.

Levelling, is the Art of finding a true horizontal Line, or the Difference of Ascent or Descent between any two Places, in order to drain Moats, Marshes, and Morasses, *&c.* or to convey Water from Place to Place.

If a Station be taken more than fifty French *Fathoms, it must be corrected from the following Table of Corrections.*

Stations.	Corrections.	Lines.	Parts.
Fathoms.	Inches.		
50	0	0	1
100	0	1	1
150	0	3	0
200	0	5	1
250	0	8	1
300	1	0	0
350	1	4	1
400	1	9	1
450	2	3	0
500	2	9	0
550	3	6	0
600	4	0	0
650	4	8	0
700	5	4	0
750	6	3	0
800	7	1	0
850	7	11	1
900	8	11	0
950	10	0	0
1000	11	0	0

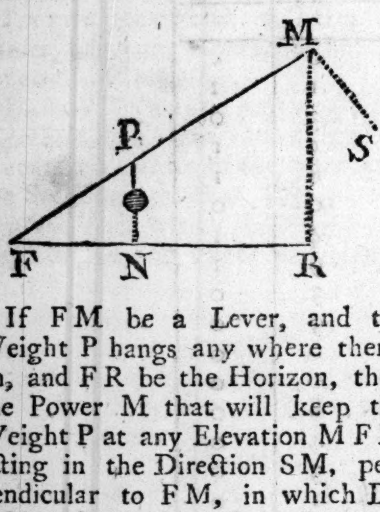
Lever, *the second mechanical Power*, is an inflexible right Line, made use of to raise Weights, either weighing nothing itself, or of such Weight as may be balanced. The Lever is threefold.



1. Sometimes the Fulcrum F is placed between the Weight P and the Power M.

2. Sometimes the Weight is between the Fulcrum and the Power.

3. And often also the Power acts between the Weight and the Fulcrum F.



If FM be a Lever, and the Weight P hangs any where thereon, and FR be the Horizon, then the Power M that will keep the Weight P at any Elevation MFR, acting in the Direction SM, perpendicular to FM, in which Direction the Action of the Power is a Maximum, will be to the Weight P, as FN to FM. For it is as FR to FM, that is, FN to FP; and as FP to FM, that is, as FN × FP : FM × FP. And since FP is in both; therefore as FN : FM.

The Action of a Power P, and the Resistance of the Weight M, increase in proportion to their Distance from the Fulcrum; and therefore that a Power may be able to sustain a Weight, it is required, that the Distance of the Point in the Lever to which it is applied, be to the Distance of the Weight, as the Weight to the Intensity of the Power; which, if it be ever so little increased, will raise the Weight.

Levity, is the Diminution or Want of Weight in any Body, when compared with another that is heavier; and in this sense is opposed to Gravity.

Libra, one of the twelve Signs of the *Zodiac*, being exactly opposite to *Aries*.

Libration *of the Moon*, (see *Evection*) is of three kinds.

1. Her *Libration* in Longitude; which is a Motion arising from the Plane of that Meridian of the Moon, (which is always, nearly, turned towards us,) being directed not to the Earth, but towards the other Focus of the Moon's Elliptical Orbit; and so to an Eye on the Earth she seems to librate to and again in Longitude, or according to the Order of the Signs in the *Zodiac*. This Libration is of no Quantity twice in each Periodical Month, *viz.* when the Moon is in her *Apogæum*, and in her *Perigæum*; for the Plane of her Meridian above-mention'd, is directed alike to both the Foci.

2. Her Libration in Latitude; which arises from hence, That her Axis not being perpendicular to the Plane of her Orbit, but inclined to it, sometimes one of her Poles, and sometimes the other, will nod (as they

they call it) or dip a little towards the Earth, (as is the Case of the Poles of the Earth towards the Sun,) and consequently she will appear to librate a little, and to show sometimes more of her Spots, and sometimes less of them, towards each Pole; which Libration depending on the Position of the Moon, in respect of the Nodes of her Orbit with the Ecliptic, (and her Axis being perpendicular nearly to the Plane of the Ecliptic) is very properly said to be in Latitude.

3. And this is compleated in the Space of the Moon's Periodical Month, or rather, while the Moon is returning again to the same Position, in respect of her Nodes.

4. There is also a third kind of Libration; by which it happens, that though another Part of her is not really obverted to the Earth, as in the former Libration, yet another is illuminated by the Sun: For since her Axis is perpendicular nearly to the Plane of the Ecliptic, when the Moon is most Southerly, in respect of the Ecliptic North Pole, some Parts nearly adjacent to it will be illuminated by the Sun; while, on the contrary, the South Pole will be in Darkness. In this Case therefore, if it happens that the Sun be in the same Line with the Moon's Southern Limit, then will she, as she proceeds from Conjunction with the Sun towards her ascending Node, appear to dip her Northern Polar Parts a little into the dark Hemisphere, and to raise her Southern Polar Parts as much into the Light. And the contrary to this will happen the next Fortnight, while the New Moon is descending from her Northern Limit; for then her Northern Polar Parts will appear to emerge out of Darkness, and the Southern Polar Parts to dip into it: And this seeming Libration, or rather these Effects of the former Libration in Latitude, depending upon the Light of the Sun, will be compleated in her Synodical Month. *Greg. Astron. Lib.* 4. *Sect.* 10.

Lifting Pieces, are Parts of a Clock which do lift up and unlock the Detents in the Clock-part.

Light, is Fire entring our Eyes in straight Lines; and by the Motion thereof that it communicates to the Fibres in the bottom of the Eye, it excites the Idea of Light.

1. A rectilinear Motion is the Motion of Light, as it appears from its being easily stopped by an Obstacle.

2. And that an irregular Motion is more proper for it, may be proved, because the Rays that come directly from the Sun to the top of a Mountain, produce no Heat; whilst in the Valley, where the Rays are agitated with an irregular Motion by several Reflexions, there is often produced a very intense Heat.

3. That there is Light where there is not Fire, is beyond all doubt; for we daily see hot Bodies that do not shine.

4. As to the Motion of Light, it is plain, that it is performed in Right Lines; but whether it be Successive or Instantaneous, is disputed; that is, whether at the same Moment that a Body begins to shine, the Light is sensible at any Distance; or whether the Light goes on successively to Places more and more distant.

5. It seems clearly to follow from several Astronomical Observations, that that Motion is successive, and Philosophers did not long doubt of it; but by some later Observations, the Conclusions drawn from the former are weakened, and we are obliged to confess that the Motion of Light has something unknown to us.

Mr.

Mr. *Romer*, from a great Number of Astronomical Observations for the space of 10 Years, inferr'd the vast Swiftness of the Motion of the Sun's Light, by means of the Eclipses of *Jupiter*'s Satellites. From whence Mr. *Huygens* in his Treatise *de Lum.* p. 8, 9. computes the Motion of Light to be 1100000000 Feet in one Second. Notwithstanding this, Mr *Cassini* and *Miraldus*, from a great Number of Astronomical Observations, will have Mr. *Romer* and *Huygens* to be mistaken. See the *Mem. de l'Academ. Royal de Scien. anno* 1707.

6. The Presence of the Air is often necessary for the Production of Light.

7. 'Tis probable, that the Rays of Light which fall upon Bodies, and by that means are reflected or refracted, begin to bend before they arrive at the Bodies; and that Light is reflected, refracted, and inflected by one and the same Principle, acting variously in various Circumstances.

8. 'Tis probable also, that Bodies and Light act on each other: Bodies in emitting, reflecting, refracting, and inflecting it; and Light, by heating them, and putting their Parts into a vibrating Motion, wherein Heat consists.

9. All fixed Bodies, when heated beyond a certain Degree, do emit Light and shine; and this Shining and Emission of Light is probably caused by the vibrating Motion of the Parts; and all other Bodies abounding with earthy Particles, and especially when they are sulphureous, when their Parts are sufficiently agitated, do emit Light; whether this Agitation be caused by Attrition, by Percussion, by Putrefaction, or a vital Motion in an Animal Body, &c. or any other way. Thus the Sea-water shines in a Storm; Quicksilver when shaken *in vacuo*; a Cat's Back or a Horse's Neck rubbed by the Hand in the dark; Wood, Flesh and Fish when putrefied.

10. Every visible Point of any Object emits Rays of Light into all Parts, from whence that Point is visible.

Sir Isaac Newton, *in his Optics, proposes the following Queries.*

1. Do not great Bodies conserve their Heat the longest, their Parts heating one another? and may not great dense and fixed Bodies, when heated beyond a certain Degree, emit Light so copiously, as by the Emission and Reaction of its Light, and the Reflexions and Refractions of its Rays within its Pores, to grow still hotter, till it comes to a certain Period of Heat, such as is that of the Sun? And are not the Sun and fixed Stars, great Earths vehemently hot, whose Heat is conserved by the Greatness of the Bodies, and the mutual Action and Reaction between them, and the Light which they emit, and whose Parts are kept from fuming away, not only by their Fixity, but also by the vast Weight and Density of the Atmospheres incumbent upon them, and very strongly compressing them, and condensing the Vapours and Exhalations which arise from them? For if Water be made warm in any pellucid Vessel emptied of Air, that Water in the *Vacuum* will bubble and boil as vehemently as it would in the open Air in a Vessel set upon the Fire, till it receives a much greater Heat. For the weight of the incumbent Atmosphere keeps down the Vapours, and hinders the Water from boiling, until it grows much hotter than is

is requisite to make it boil *in vacuo*. Also a Mixture of Tin and Lead being put upon a red-hot Iron *in Vacuo*, emits a Fume and Flame; but the same Mixture in the open Air, by reason of the incumbent Atmosphere, does not so much as emit any Fume which can be perceived by Sight. In like manner the great Weight of the Atmosphere, which lies upon the Globe of the Sun, may hinder Bodies there from rising up, and going away from the Sun in the form of Vapours and Fumes, unless by means of a far greater Heat than that which on the Surface of our Earth would very easily turn them into Vapours and Fumes. And the same great Weight may condense those Vapours and Exhalations as soon as they shall at any time begin to ascend from the Sun, and make them presently fall back again into him, and by that Action increase his Heat much after the manner that in our Earth the Air increases the Heat of a Culinary Fire. And the same Weight may hinder the Globe of the Sun from being diminished, unless by the Emission of Light, and a very small quantity of Vapours and Exhalations.

2. Do not several sorts of Rays make Vibrations of several Bignesses, which, according to their Bignesses, excite Sensations of several Colours, much after the same manner that the Vibrations of the Air, according to their several Bignesses, excite Sensations of several Sounds? And particularly, do not the most refrangible Rays excite the shortest Vibrations for making a Sensation of deep Violet the least refrangible, the largest for making a Sensation of a deep Red, and the several intermediate sorts of Rays, Vibrations of several intermediate Bignesses to make Sensations of the several intermediate Colours?

3. May not the Harmony and Discord of Colours arise from the Proportions of the Vibrations propagated through the Fibres of the Optick Nerves into the Brain, as the Harmony and Discord of Sounds arise from the Proportions of the Vibrations of the Air? For some Colours, if they be viewed together, are agreeable to one another, as those of Gold and Indigo, and others disagree.

See more of the Nature of Light in Dr. *Boerhaave*'s *Chemistry*.

Like Quantities, in *Algebra*, are such as are expressed by the same Letters equally repeated in each Quantity. Thus, $5\,b$ and $4\,b$, and $10\,ff$ and $2\,ff$, are like Quantities; $5\,b$, and $4\,bb$, and $10\,ff$, and $2\,fff$, are unlike ones; because the Quantities have not every where the same Dimensions, nor are the Letters equally repeated.

Like Signs, in *Algebra*, are when both are Affirmative, or both Negative; but if one be Affirmative, and the other Negative, they are Unlike Signs. Thus, $+\,30\,d$, and $+\,2\,d$, have Like Signs, but $-\,3\,ff$, and $+\,ff$, have Unlike Signs.

Like Figures. See *Similar Figures*.

Like Figures, are in the duplicate *Ratio* of their Homologous Sides.

Like Arches *of a Circle*, are such as contain an equal Number of Degrees.

Like Solid Figures, are to one another in the duplicate *Ratio* of their Homologous Sides.

Limb, signifies the uttermost Border or graduated Edge of an Astrolable, Quadrant, or the like Mathematical Instrument; or the Circumference

cumference of the Primitive Arch in any Projection of the Sphere *in Plano*: Alſo the outermoſt Border of the Sun's or Moon's Diſk, in an Eclipſe of either Luminary.

LIMBERS, in Gunnery, are a kind of Train joined to the Carriage of a Cannon upon a March; it is compoſed of two Shafts, wide enough to receive a Horſe between them, (which Horſe is called the Fillet-Horſe.) Theſe Shafts are joined by two Bars of Wood, and a Bolt of Iron at the End, and have a Pair of ſmall Wheels. On the Axel-Tree riſes a ſtrong Iron Spike, on which the Train of the Carriage is put upon a March: But when a Gun is on Action, theſe *Limbers* are run out behind her.

LIMIT *of a Planet*, is the greateſt Heliocentrick Latitude. Which ſee.

LIMITED PROBLEM, ſignifies a Problem that hath but one, or a determined Number of Solutions; as to make a Circle paſs thro' three Points given, not lying in a Right Line, to deſcribe an Equilateral Triangle on a Line given, *&c.*

LINCH-PINS, are thoſe Pins that keep on the Carriage of a Piece of Ordnance.

LINE, *a Line in Geometry*, is a Quantity extended in Length only, and is ſuppoſed to have no Breadth or Thickneſs. It is made by the Motion of a Point.

LINE is alſo the 12th Part of an Inch.

LINE of { True Place / Apparent Place } of a Planet, is a right LINE drawn from { The Earth's Centre / Eye of the Spectator } thro' the Planet, and continued as far as the fixed Stars.

LINE *of Meaſures*, in the Stereographic Projection of the Sphere *in Plano*, is that Line in which the Plane of a great Circle perpendicular to the Plane of the Projection, and that oblique Circle which is projected, interſects the Plane of the Projection: Or it is the common Section of a Plane paſſing thro' the Eye's Point, and thro' the Centre of the Primitive, and at Right Angles to any oblique Circle which is to be projected, and in which the Centre and Pole of ſuch a Circle will be found.

LINE *of Direction of the Earth's Axis*, in the *Pythagorean* Syſtem of Aſtronomy, is the Line connecting the two Poles of the Ecliptic, and of the Equator, when they are pro jected on the Plane of the former.

LINE *of the Section*, in Perſpective, is the Interſectionor Contact of the plain to be projected with the Glaſs or Diaphanous Plane.

LINE of *Lines*, on the Sector, is a Scale of equal Parts on each Leg, and running from the Centre. This is divided into 100 equal Parts, and ſometimes into more, when the Inſtrument is large.

LINE *of Numbers.* See *Gunter's Line.*

LINE, in Fortification, is that which is drawn from one Point to another, in delineating a Plane upon Paper: But in the Field it is ſometimes taken for a Ditch bounded with its Parapet, and ſometimes for a Row of Gabions, or Sacks of Earth, extended in length on the Ground, to ſerve as a Shelter againſt the Enemy's Fire. Thus they ſay, when the Trenches were carried on within 30 Paces of the Glacis, we drew two Lines, one on the Right Hand, and the other on the Left, for a Place of Arms.

LINE CAPITAL, is that which is drawn from the Angle of the Gorge to the Angle of the Baſtion.

LINE

Line Central, is that which is drawn from the Angle of the Centre, to that of the Baſtion.

Line *of Defence*, is that which repreſents the Courſe of the Bullet of any ſort of Fire-Arms, more eſpecially of a Muſquet-Ball, according to the Situation which it ought to have to defend the Face of the Baſtion.

Line *of Defence Fixed or Fichant*, is that which is drawn from the Angle of the Curtain, to the flanked Angles of the oppoſite Baſtion; nevertheleſs without touching the Face of the Baſtion. This muſt never exceed 800 Feet, which they reckon the Diſtance a Muſquet-Ball will do Execution.

Line *of Defence Razant*, is that which being drawn from a certain Point of its Curtain, razeth the Face of the oppoſite Baſtion. This is called alſo the Line of Defence Stringent or Flanking.

Line *of Approach, or of Attack*, ſignifies the Work which the Beſiegers carry on under Covert, to gain the Moat, and the Body of the Place.

Line *of Circumvallation*, is a Line or Trench cut by the Beſiegers within Cannon-ſhot of the Place, which rangeth round their Camp, and ſecures its Quarters againſt the Relief of the Beſieged.

Line *of Contravallation*, is a Ditch bordered with a Parapet, which ſerves to cover the Beſiegers on the Side of the Place, and to ſtop the Salleys of the Garriſon.

Lines *within ſide*, are the Moats towards the Place, to prevent the like Salleys.

Lines *without ſide*, are the Moats towards the Field, to hinder Relief.

Lines *of Communication*, are thoſe that run from one Work to another. But the Line of Communication, more eſpecially ſo called, is a continued Trench, with which a Circumvallation or Contravallation is ſurrounded, and which maintains a Communication with all its Forts, Redoubts, and Tenables.

Line *of the Baſe*, is a right Line which joins the Points of the two neareſt Baſtions.

To line a Work, is to ſtrengthen a Rampart with a firm Wall, or to encompaſs a Parapet or Moat with a good Turff, &c.

Linea Apsidum, *or the Line of the Apſes*, in the old Aſtronomy, is a Line paſſing through the Center of the World, and of the Excentric; and whoſe two Ends are, one the *Apogæum*, the other the *Perigæum* of the Planet. That Part of this Line which lies between the Center of the World and that of the Excentric, is called the Excentricity.

Line *of greateſt or leaſt Longitude of a Planet*, is that Part of the *Linea Apſidum* reaching from the Center of the World to the *Apogæum*, or *Perigæum* of the Planet.

Line *of mean Longitude*, is one drawn through the Centre of the World at Right Angles, to the *Linea Apſidum*, and is there a new Diameter of the Excentric, or Different; and its extreme Points are called the mean Longitude.

Line *of the mean Motion of the Sun*, in the old Aſtronomy, is a Right Line drawn from the Center of the World as far as to the Zodiac of the *Primum Mobile*; and parallel to a Right Line drawn from the Center of the Excentric, to the Center of the Sun; which latter Line they call alſo the Line of the mean Motion of the Sun in the Excentric, to diſtinguiſh it from the former; which is the Line of mean Motion in the Zodiac of the *Primum Mobile*.

Line *of the Sun's true Motion*, is a Line drawn from the Centre of the

the World to the Center of the Sun, and produced as far as the Zodiac of the *Primum Mobile*.

LINE HORIZONTAL, is a right Line parallel to the Horizon.

1. In Dialling, it is the common Section of the Horizon and the Dial-Plane.

2. In Perspective, it is the common Section of the Horizontal Plane, and that of the Draught or Representation, and which passes thro' the principal Point.

LINE GEOMETRICAL, in Perspective, is a Right Line drawn any how on the Geometrical Plane.

LINE TERRESTRIAL, in Perspective, is a Right Line, wherein the Geometrical Plane and that of the Picture or Draught intersect one another.

LINE *of the Front*, in Perspective, is the common Section of the vertical Plane and of the Draught.

LINE *of Station*, in Perspective, according to some Writers, is the common Section of the Vertical and Geometrical Planes. Others, as *Lamy*, mean by it the perpendicular Height of the Eye above the Geometrical Plane. Others, a Line on that Plane, and perpendicular to the Line expressing the Height of the Eye.

LINE OBJECTIVE, in Perspective, is the Line of an Object, from whence the Appearance is sought for in the Draught or Picture.

LINE *of Gravitation of any heavy Body*, is a Line drawn through its Center of Gravity, and according to which it tends downwards.

LINE *of Direction of any Body in Motion*, is that according to which it moves, or which directs and determines its Motion.

LINE *of the swiftest Descent of a heavy Body*, is the *Cycloid*.

LINE *of the Anomaly of a Planet*, in the *Ptolemaic* System, is a Right Line drawn from the Center of the Excentric to the Center of the Planet.

LINE *of the* Apogæum *of a Planet*, in the Old Astronomy, is a right Line drawn from the Centre of the World, through the Point of the *Apogæum*, as far as the Zodiac of the *Primum Mobile*.

LINE *of the Nodes of a Planet*, in the New Astronomy, is a Right Line drawn from the Planet to the Sun, being the common Intersection of the Plane of the Planet's Orbit with that of the Ecliptic.

LINE EQUINOCTIAL, in Dialling, is the common Intersection of the Equinoctial, and the Plane of the Dial.

LINED MOAT, a Term in Fortification. See *Moat*.

LINEAR NUMBERS, are such as have relation to Length only; as (*v. gr.*) such as represent one Side of a plain Figure; and if the plain Figure be a Square, the *Linear Number* is called a *Root*.

LINEAR PROBLEM, in Mathematics, is such an one as can be solved geometrically by the Intersection of two Right Lines. This is called a *Simple Problem*, and is capable but of one Solution.

LINE SUBSTYLAR, is that Line on which the Style or Cock of a Dial is erected, and is the Representation of such an Hour-Circle as is perpendicular to the Plane of that Dial.

LINE SYNODICAL, in reference to some Theories of the Moon, is a Right Line supposed to be drawn through the Centres of the Earth and the Sun; and if it be produced quite through the Orbits, 'tis called the

LINE *of the true Syzygies*: But a Right Line imagined to pass through the Earth's Centre, and the mean Place of the Sun is called the

LINE *of the mean Syzygies*.

LINES *of Chords, Sines, Tangents, Secants*,

Secants, *Versed Sines*, &c. See *Scale*.

Linstock, is a short Staff of Wood about three Foot long, having at one End a Piece of Iron divided into two Branches, each of which hath a Notch to hold a Piece of Match, and a Screw to fasten it there. The other End of the Staff is shod also with Iron, and pointed to stick into the Ground; 'tis used by the Gunners in firing Cannon.

Liquids, are such Bodies as have all the Properties of Fluidity, (see that Word;) and withal, have their Particles so formed, figured, or disposed, that they do adhere to the Surfaces of such Bodies as are immersed in them, which we call *Wetting*; and this Property of Liquid Bodies is sometimes called *Humidity* or *Moisture*.

List, in Architecture, is a little square Moulding, serving to crown or accompany a larger, or on occasion to separate the Flutings of a Column. It is sometimes called *Fillet*, and sometimes *Square*.

Listel, a small Band, or a kind of a Rule in the Mouldings of Architecture: Also the Space between the Channellings of Pillars.

Literal Algebra. See *Algebra*.

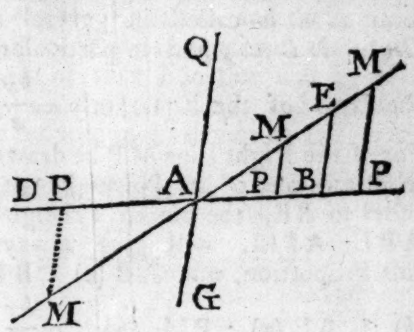
Liziere, a Term in Fortification, being the same with *Berm*. Which see.

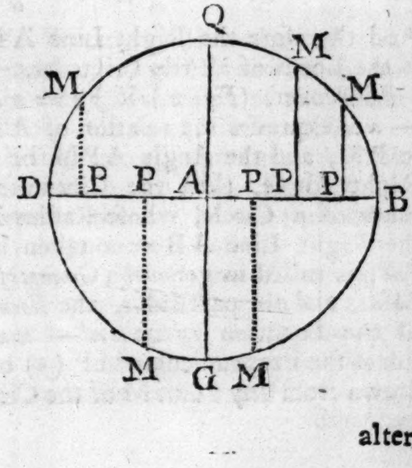
Local Problem, in Mathematics, is such an one as is capable of an infinite Number of different Solutions: So that the Point which is to resolve the Problem, may be indifferently taken within a certain Extent. As suppose any where, in such a Line, within such a plain Figure, &c. which is called a *Geometric Locus*, and the Problem is said to be a local or indetermined one, and this local Problem may be either simple, when the Point sought is in a Right Line; Plane, when the Point sought is in the Circumference of a Circle; Solid, when the Point required is in the Circumference of a Conic Section; or lastly Sursolid, when the Point is in the Perimeter of a Line of an higher kind.

Lock-Spit, a Term in Fortification, signifying the small Cut or Trench made with a Spade, to mark out the first Lines of any Work that is to be made.

Locking-Wheel. See *Count-Wheel*, a Term in Watch-work.

Locus. If there be two unknown and indeterminate Right Lines AP, PM, making any Angle (APM) with each other at pleasure; and if the Beginning of one of them, *viz.* AP (which may be called x) be fixed in the Point A, and the said AP indefinitely extends itself along a right Line given in Position; and the other PM which may be called y, continually





alters

alters its Poſition, and is always parallel to itſelf: (that is, if all the PM's be parallel to one another.) Then if there be an Equation, wherein are both the unknown Quantities x and y, mix'd with known ones, which expreſſes the Relation of every AP (x) to its Correſpondent PM (y), the Curve paſſing thro' the Extremities of all the Values of y, that is, through all the Points M, is called in general a *Geometric Locus*; and in particular the *Locus* of that Equation.

1. For Example: Let us ſuppoſe, (*Fig.* 1.) that the Equation $y = \frac{bx}{a}$ expreſſes always the Relation of the Line AP (x) to PM (y), which make any Angle APM at pleaſure with one another: In the Line AP aſſume AB$=a$, and from B draw BE$=b$, parallel to PM, and on the ſame ſide; then the indefinite Line AM is called in general a *Geometric Locus*; and in particular, the *Locus* of the Equation $y = \frac{bx}{a}$. For if the Right Line MP be drawn from any one of its Points M parallel to BE, the ſimilar Triangles ABE, APM, will give always this Proportion, *viz.* AB (a) : BE (b) :: AP (x) : PM (y) $= \frac{bx}{a}$. And therefore the Right Line AE is the Locus of all the Points M.

Moreover, (*Fig.* 2.) if $yy = aa - xx$ expreſſes the relation of AP to PM, and the Angle APM be a Right Angle, then the Circumference of a Circle, whoſe Radius is the Right Line AB $= a$ taken in AP, is called in general a *Geometric Locus*, and, in particular, the *Locus* of the Equation $yy = aa - xx$. For if the Perpendicular MP (y) be drawn from any Point M of the Circumference, then by the Nature of the Circle, we ſhall have always $\overline{PM}^2$ (yy) $=$ DP $\times$ PB ($aa - xx$,) ſuppoſing BD the Diameter of the Circle. Therefore the Locus of all the Points M is the Circumference of a Circle.

3. If all the PM's be ſuppoſed to tend from one ſide of the Line AB, as towards Q; and then they be ſuppoſed to tend from the other ſide of the ſaid Line, as towards G; then it muſt be obſerved, that their Values from Poſitives (which they are ſuppoſed to be when tending towards Q,) will become Negative, and ſo ſhall we have PM $= -y$. Moreover, if the Point P be ſuppoſed to fall from A towards B, and afterwards the contrary way, as from A towards D; then all the AP's on this ſide A will become negative, and conſequently we have AP $= -x$. And a geometric Locus muſt paſs through the Extremities of all the Values (as well poſitive as negative) of one of the unknown Quantities y, which anſwer to the Values both poſitive and negative of the other unknown Quantity x. Therefore, if the Right Line QAG be drawn parallel to PM, a geometric Locus may be found in the four Angles BAQ, BAG, GAD, DAQ; as in the ſecond Example (*Fig.* 2.) or only in ſome of the Angles, as in the firſt Caſe (*Fig.* 1.) For in the ſecond Example, ſuppoſe that AP be $= x$, and PM $= y$, the Point M being taken firſt in the Quadrant QB; then if the Point M be taken afterwards in the Quadrant GB, we ſhall have AP $= x$, and PM $= -y$; if M be taken on DG, we ſhall have AP $= x$, and PM $= -y$: And finally, if M be taken on DQ, we ſhall have AP $= -x$, and PM $= y$. And in all theſe Caſes (by the Nature of the Circle) there will come out the ſame Equation

tion $yy = aa - xx$; because the Squares of $+y$, and $+x$, are the same in all Cases, *viz.* yy and xx. Moreover, in the first Example, if you make AP$=x$, and PM$=y$, in the first Point M taken (on the same side as E) upon AE (produced towards A) in the Angle GAD, we shall have AP $= -x$, and PM $= -y$; and since the Triangles ABE, APM, are similar, the following Proportion will be formed, *viz.* AB (a) : BE (b) :: AP ($-x$) : PM ($-y$) $= -\frac{bx}{a}$; and therefore $y = \frac{bx}{a}$. Which is the same Equation as was formed, by supposing the Point M to fall in the Angle BAQ.

4. The ancient Geometricians did call *Plain Loci*, such that are Right Lines or Circles; and *Solid Loci*, those that are Parabola's, Ellipses, or Hyperbola's; and *Surd-Solid Loci*, such that are Curves of a superior Gender than Conic Sections. But the Moderns do distinguish *Geometric Loci* into different Kinds or Degrees. For under the first Degree are comprehended all the *Loci*, wherein the unknown Quantities x and y are found in Equations only of one Dimension; under the second, all those wherein those unknown Quantities have two Dimensions, and so on; where you may observe, that there must be no Rectangle or Product of the unknown Quantities x and y in the Equations for the *Loci* of the first Kind or Degree; and in the Equations for the second, those Quantities must form a Product, as xy of no more than two Dimensions; and in Equations for the third, a Product xxy, or xyy, of three Dimensions, &c.

5. The Terms of the Equation of a *Locus* are said to be different, when either of the unknown Quantities x and y, or both of them together, are found therein of different Dimensions: So in the first Degree, if this Equation be proposed, $y - \frac{bx}{a} + c = o$, the Terms y, $-\frac{bx}{a}$, c will be different. Moreover, in the second Degree, if you suppose $yy + \frac{2bxy}{a} - 2cy - \frac{fxx}{a} + gx + hx - hh + ll = o$; then the Terms yy, $\frac{2bxy}{a}$, $-2cy$, $-\frac{fxx}{a}$, $gx + hx$, $-hh + ll$, shall be every one of them different.

6. When the unknown Quantities x and y, have but one Dimension in a given Equation, and their Product xy is not in the same, then the *Locus* of that Equation will be always a straight Line; and it may be reduced to some one of the four following Formula's; 1. $y = \frac{bx}{a}$. 2. $y = \frac{bx}{a} + c$. 3. $y = \frac{bx}{a} - c$. 4. $y = c - \frac{bx}{a}$.

6. When any Equation of two Dimensions is given, and it is required to know which of the Conic Sections will be the *Locus* of it:

Bring over all the Terms of the Equation to one side; so that one Member thereof be o, then there may happen two Cases:

Case 1. When the Plane xy is not in the given Equation. 1. If there be but one of the Squares yy or xx therein, then the *Locus* will be a Parabola. 2. If both the

Squares yy and xx are found therein with the same Signs, then the Locus will be an Ellipsis or a Circle. 3. If the said two Squares are found therein with different Signs, then the Locus thereof will be an Hyperbola, or the opposite Sections regarding their Diameters.

Case 2. When the Plane xy happens to be in a given Equation. 1. If neither of the Squares yy and xx, or but one of them, are found in the Equation, then the Locus will be an Hyperbola between its Asymptotes. 2. If the Squares yy and xx are found therein with different Signs, then the Locus shall be an Hyperbola regarding its Diameters. 3. If the said two Squares have the same Signs, the Square yy must be freed from Fractions, and then the Locus shall be a Parabola, when the Square of half the Fraction multiplying xy be equal to the Fraction multiplying xx; an Ellipsis or Circle, when the same is less; and finally, an Hyperbola, or two opposite ones, regarding their Diameters, when the same is greater.

The best way of finding the Loci of Equations of two Dimensions, is by extracting the Root after the manner of *Des Cartes*. See his *Geometry*; as also *Sterling*'s *Illustratio Linearum tertii Ordinis*. The Doctrine of these Loci is very well handled too by *De Witt*, in his *Elementa Curvarum*; Mr. *Craige*, in his *Tractatus de Figurarum Curvilinearum Quadraturis & Locis Geometricis*; and the Marquis *de l'Hospital*, in his *Analytic Treatise of Conic Sections*, have treated of this Subject; and *Bartholomæus Intieri*, in his *Aditus ad nova Arcana Geometrica detegenda*, has shewn how to find the Loci of Equations of the higher Orders: So also has Mr. *Sterling*, in his Treatise aforesaid, given an instance or two of finding the Loci of Equations of three Dimensions. *Euclid*, *Apollonius*, *Aristæus*, *Fermat*, *Viviani*, have also wrote of the Loci.

Locus ad Lineam, is when the Point that satisfies the Problem, is found in a Line, whether Right or Curve, and that by reason of the Want of one Condition, only to render the Problem determinate altogether.

Locus ad Solidum, is when three Conditions are wanting to the Determination of the Point sought, and so it will be found in a Solid; and this may be included either under a Plane, Curve, or mix'd Superficies, and those either determinate or indefinitely extended.

Locus ad Superficiem, is when there being two Conditions wanting to determine any Point that satisfies any Problem, that Point may be taken throughout the Extension of some Superficies, whether Plane or Curve.

As the Locus of an Equation, wherein there are two variable Quantities, is a Right Line or a Curve Line; so the Locus of an Equation containing three unknown Quantities, will be always a Superficies. As the Equation $xx + yy + zz = aa$, represents the Superficies of a Sphere, whose Radius is a, wherein x flows along a Diameter of a great Circle from the Centre, y flows at right Angles upon the Plane of the Circle from the Extremity of x, and z is a Perpendicular from the Extremity of y, to the Superficies of the Sphere. In like manner $\frac{bbxx}{aa} = yy + zz$, represents the Curve Superficies of a right Cone, where x flows along the Axis from the Vertex, y is perpendicular to x, z to y, a equal to the Axis, and b equal to the Radius of the Base. See something of this in a *French* Treatise entitled *Recherches*

cherches ſur les Courbes a double Courbure.

LODGMENT *of an Attack*, is a Work caſt up by the Beſiegers, during their Approaches in a dangerous Poſt, where it is abſolutely neceſſary to ſecure themſelves againſt the Enemy's Fire; as in a Cover'd-Way, in a Breach, in the bottom of a Moat, or elſewhere. This Lodgment conſiſts of all the Materials that are capable to make Reſiſtance, *viz.* Barrels and Gabions of Earth, Paliſadoes, Woolpacks, Mantelets, Faggots, *&c.*

LOG-LINE, is one to which the Log is faſten'd, which is wound about a Reel for that purpoſe, fixed in the Gallery of the Ship. This Line, for about 10 Fathom from the Log, hath, or ought to have no Knots or Diviſions; becauſe ſo much ſhould be allowed for the Log's being clear out of the Eddy of the Ship's Wake before they turn up the Glaſs; but then the Knots or Diviſions begin, and ought to be at leaſt 50 Foot from one another; tho' the common erroneous Practice at Sea is to have them but ſeven Fathom, or 42 Foot diſtance.

Tho' this at beſt be but a precarious way, 'tis however the moſt exact of any in uſe, and much better than that of the *Spaniards* and *Portugueſe*, who gueſſed at the Ship's Way by the running of the Froth or Water by the Ship's ſide; or than that of the *Dutch*, who uſed to heave over a Chip into the Sea, and ſo to number how many Paces they could walk on the Deck, while the Chip ſwam or paſſed between any two Marks or Bolt-Heads on the ſide.

LOGARITHMS, are the Indexes or Exponents, (moſtly whole Numbers and decimal Fractions, conſiſting of 7 Places of Figures at leaſt) of the Powers or Roots (chiefly broken) of a given Number, yet ſuch Indexes or Exponents, that the ſeveral Powers or Roots they expreſs are the natural Numbers 1, 2, 3, 4, 5, *&c.* to 10 or 100000, *&c.* (as if the given Number be 10, and its Index be aſſumed 1,0000000, then the 0,0000000 Root of 10, which is 1, will be the Logarithm of 1; the 0,301036 Root of 10, which is 2, will be the Logarithm of 2. the 0,477121 Root of 10, which is 3, will be the Logarithm of 3; the 0,612060 Root of 10, the Logarithm of 4. the 1,041393 Power of 10 the Logarithm of 11; the 1,079181 Power of 10 the Logarithm of 12; and ſo on,) being chiefly contrived for the Eaſe and Expedition of performing Arithmetical Operations in large Numbers, pointing out the Product of two Numbers by the Addition of their Logarithms, the Quotient of their Diviſion by the Subſtraction of their Logarithms, and the Powers and Roots by the Doubling, Tripling, *&c.* Halving, Triſecting, *&c.* the Logarithms; and founded upon this Conſideration, that if there be any Row of geometrical proportional Numbers, as 1, 2, 4, 8, 16, 32, 64, 128, 256, *&c.* or 1, 10, 100. 1000, 10000, *&c.* and as many Arithmetical Progreſſional Numbers adapted to them, or ſet over them, beginning with 0, thus,

0, 1, 2, 3, 4, 5, 6, 7, *&c.*
1, 2, 4, 8, 16, 32, 64, 128, *&c.*

or

0, 1, 2, 3, 4, *&c.*
1, 10, 100, 1000, 10000, *&c.*

then will the Sum of any two of thoſe Arithmetical Progreſſionals added together be that Arithmetical Progreſſional, which anſwers to, or ſtands over the Geometrical Progreſſional, being the Product of the Multiplication of thoſe two Geometrical Progreſſionals under which the two aſſum'd A-

rithmetical Progressionals stand; and if those Arithmetical Progressionals be subtracted from each other, the Remainder will be the Arithmetical Progressional standing over that Geometrical Progressional which is the Quotient of the Division of the two Geometrical Progressionals belonging to the two first assumed Arithmetical Progressionals, and the Double, Triple, &c. of any one of the Arithmetical Progressionals, will be the Arithmetical Progressional standing over the Square, Cube, &c of that Geometrical Progressional, which the assum'd Arithmetical Progressional stands over; as well as the $\frac{1}{2}$, $\frac{1}{3}$, &c. of that Arithmetical Progressional, will be the Geometrical Progressional answering to the Square Root, Cube Root, &c. of the Arithmetical Progressional over it; and from hence arises the following common, tho' lame and imperfect Definition of *Logarithms*, viz. *that they are so many Arithmetical Progressionals answering to the same Number of Geometrical ones.* Whereas if any one looks into the Tables of Logarithms, he will find that these do not at all run on in an Arithmetical Progression, nor the Numbers they answer to in a Geometrcial one. These last being themselves Arithmetical Progressionals.

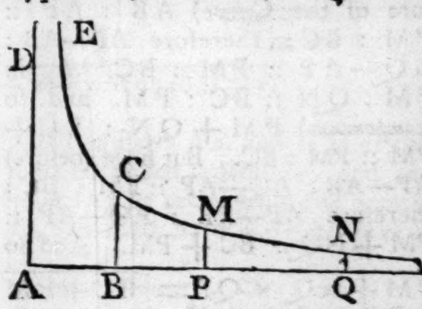
Dr. *Wallis*, in his History of *Algebra*, calls Logarithms the Indexes of the Ratio's of Numbers to one another.— Dr. *Halley*, in the *Philosophical Transactions*, N° 216. says, they are the Exponents of the Ratio's of Unity to Numbers.— So also Mr. *Cotes*, in his *Harmonia Mensurarum*, says, they are the Numerical Measures of Ratio's; but all these convey but a very confused Notion of Logarithms. Nay, if what the great Dr. *Barrow* says, in one of his Mathematical Lectures, be admitted for Truth, (where he treats of the Nature of a Ratio, and denies it to be any manner of Quantity.) those Gentlemen's Definitions must be either Nonsense, or very near it.

The first Makers of the Logarithms had a very laborious and difficult Task to perform; they first made choice of their Scale or System of Logarithms, that is, what Sett of Arithmetical Progressionals should answer to such a Set of Geometrical ones, for this is entirely arbitrary; and for some Reasons the Decuple Geometrical Progressionals, 1, 10, 100, 1000, 10000, &c. and the Arithmetical one, 0, 1, 2, 3, 4, &c. or 0,000000; 1,000000; 2,000000; 3,000000; 4,000000, &c. was thought most convenient. After this they were to get the Logarithms of all the intermediate Numbers between 1 and 10, 10 and 100, 100 and 1000, 1000 and 10000, &c. *Hic Labor hoc Opus fuit.* But first of all they were to get the Logarithms of the prime Numbers 3, 5, 7, 11, 13, 17, 19, 23, &c. and when these were once had, it was easy to get those of the Compound Numbers made up of the prime ones, by the Addition or Subtraction of their Logarithms.

In order to this, they found a mean Proportional between 1 and 10, and its Logarithm will be $\frac{1}{2}$ that of 10; and so given, then they again found a mean Proportional between the Number first found and Unity, which Mean will be nearer to 1 than that before, and its Logarithm will be $\frac{1}{2}$ of the former Logarithm, or $\frac{1}{4}$ of that of 10; and having in this manner continually found a mean Proportional between 1 and the last mean, and bissected the Logarithms, they at length, after finding 54 such means, came to a Number 1,000000000000000 12781914932003234 42 so near to 1 as not to differ from it so much

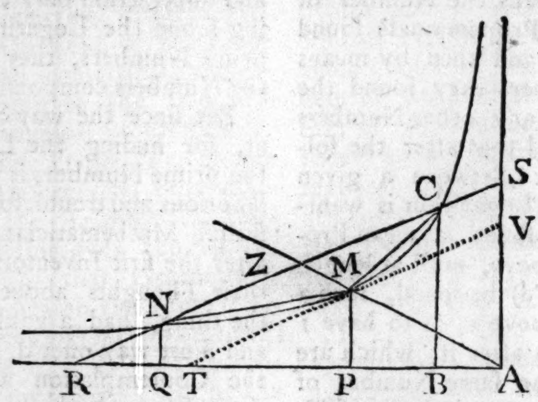
as $\frac{1}{10000000000000000}$ Part, and found its Logarithm to be 0,0000 0000000000000555111512312578 2702, and, 0000000000000001278 1914932003235 to be the Difference whereby 1 exceeds the Number of Roots or mean Proportionals found by Extraction, and then by means of these Numbers they found the Logarithms of any other Numbers whatsoever, and that after the following manner: Between a given Number whose Logarithm is wanted and 1, they found a mean Proportional as above, until at length a Number (mix'd) be found, such a small Matter above 1, as to have 1 and 15 Cyphers after it, which are followed by the same Number of significant Figures; then they said, as the last Number mentioned above is to the mean Proportional thus found, so is the Logarithm above, *viz.* 0,00000000000000000555111 5123125782702 to the Logarithm of the mean Proportional Number such a small Matter exceeding 1, as but now mentioned; and this Logarithm being as often doubled as the Number of mean Proportionals (form'd to get that Number) will be the Logarithm of the given Number. And this was the method that Mr. *Briggs* took, to make the Logarithms. But if they are to be made to only seven Places of Figures, which are enough for common Use, they had only occasion for to find 25 mean Proportionals, or, which is the same thing, to extract the $\frac{1}{33554432}$th Root of 10. Now having the Logarithms of 3, 5, and 7, they easily got those of 2, 4, 6, 8, and 9; for since $\frac{10}{5}=2$, the Logarithm of 2 will be the Difference of the Logarithms of 10 and 5; the Logarithm of 4, will be two times the Logarithm of 2; the Logarithm of 6, will be two times the Logarithm of 3; and the Logarithm of 9, three times the Logarithm of 3. So also having found the Logarithms of 13, 17, and 19, and also of 23 and 29, they did easily get those of all the Numbers between 10 and 30, by Addition and Subtraction only; and so having found the Logarithms of other prime Numbers, they got those of the Numbers compounded of them.

But since the way above hinted at, for finding the Logarithms of the prime Numbers is so intolerably laborious and troublesome, the more skilful Mathematicians that came after the first Inventors, employing their Thoughts about abbreviating the thing, had a vastly more easy and short way offer'd to them from the Contemplation and Mensuration of hyperbolic Spaces contained between the Portions of an Asymptote, Right Lines perpendicular to it, and the Curve of the Hyperbola: For if E C N be an Hyperbola, and A D, A Q the A-



symptotes, and AB, AP, AQ, &c. taken upon one of them be represented by Numbers, and the Ordinates B C, PM, QN, &c. be drawn from the several Points B, P, Q, &c. to the Curve, then will the Quadriline Spaces B C M P, P M N Q, &c. *viz.* their Numerical Measures, be the Logarithms of the Quotients of the Division of AB by AP; AP by AQ, &c. Since when AB, AP, AQ, &c. are continual Proportionals, the said Spaces are equal, as is demonstrated by several Writers concerning Conic Sections. Amongst which, see

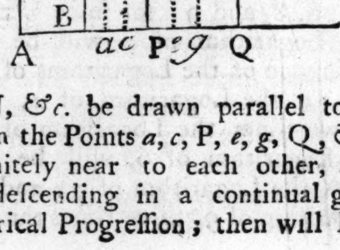
see the *Quadrature of the Circle*, by *Gregory St. Vincent*; and the Márquis *de la Hospital*'s *Conic Sections*; which likewise may be briefly demonstrated thus: Join the Points N and C by a Right Line, which continue out Book-ways to meet the Asymptotes in R and S. Also join N M, M C, draw the Tangent T M V thro' M, and draw the



the Right Line A M Z cutting N S in Z. Now since (by Supposition) AP : AB :: AQ : AP; therefore (*dividendo*) AP—AB : AQ — AP :: AB : AP. But since (by the Nature of the Curve) AB : AP :: PM : BC; therefore AP—AB : AQ—AP :: PM : BC. Again PM : QN :: BC : PM. and so (*componendo*) PM + QN : BC + PM :: PM : BC. But since (before) AP—AB : AQ—AP :: PM : BC; therefore AP—AB : AQ—AP :: PM + NQ : BC + PM. And so $\overline{PM+NQ} \times QP = \overline{BC+PM} \times PB$, and the half of the one equal to the half of the other; that is, the right-lin'd Trapeziums QNMP, PMCB are equal.

Again, since (by Nat. Curve) TP = AP and RQ = AB, and BC : PM :: PM : QN (by Sup.) and AP : AB :: BC : PM; therefore TP (AP) : PM :: RQ (AB) : QN. Wherefore the Triangles RNQ, TMP are similar; and so the Right Line RS is parallel to the Tangent TV. Consequently NC will be an Ordinate to the Diameter AZ, and NZ = ZC, and the right-lin'd Triangle NZM = ZCM, and the Hyperbolic Segments NMN, MCM equal. Wherefore at length the Trapezium QNMP — Segment NMN is = Trapezium PMCB — Segment MCM; that is, the Hyperbolic Spaces QNMP, PMCB are equal.

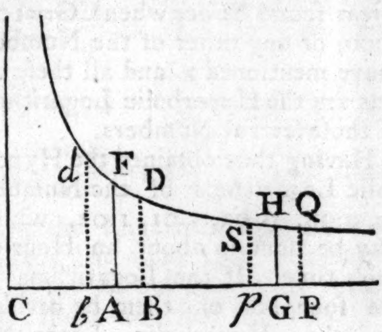
This may be demonstrated without considering any one Property of the Hyperbola, except that of the Rectangles AB × BC, AP × PM, AQ × QN, &c. being equal to one another; for suppose BC to be a given Ordinate, and let an infinite Number of Ordinates *ab*, *cd*, PM, *ef*, *gh*,



QN, &c. be drawn parallel to it from the Points *a*, *c*, P, *e*, *g*, Q, &c. infinitely near to each other, and all descending in a continual geometrical Progression; then will B*a*, *a c*,

ac, cP, Pe, eg, gQ, &c. be continual Geometrical Progressionals; and so all the little Rectangles $CB \times Ba$, $ab \times ac$, $cd \times cP$, $PM \times Pe$, $ef \times eg$, $gh \times gQ$, &c. will be equal to one another; and any Number BM of them will be equal to the same Number PN of them: that is, since the hyperbolic Space BN differs but by an infinitely small Quantity from the Sum of all such little Rectangles, the hyperbolic Space $BCMP$ will be equal to the hyperbolic Space $PMNQ$. Having thus shewn that these hyperbolic Spaces numerically expressed may be taken for Logarithms, I think it may not be amiss to shew a short Specimen from our great Sir *Isaac Newton*, of the Method how to measure these Spaces, and consequently how the Logarithms may be constructed.

Let $CA = AF$ be $= 1$, and $AB = Ab = x$; then will $\frac{1}{1+x}$ be $= BD$, and $\frac{1}{1-x} = bd$; and putting these Expressions into *Series's*, it will be



$\frac{1}{1+x} = 1 - x + x^2 - x^3 + x^4 - x^5$, &c. and $\frac{1}{1-x} = 1 + x + x^2 + x^3 + x^4 + x^5$, &c. and $\frac{\dot{x}}{1+x} = \dot{x} - x\dot{x} + x^2\dot{x} - x^3\dot{x} + x^4\dot{x} - x^5\dot{x}$, &c. and $\frac{\dot{x}}{1-x} = \dot{x} + x\dot{x} + x^2\dot{x} + x^3\dot{x} + x^4\dot{x} + x^5\dot{x}$, &c. and taking the Fluents, we shall have the Area $AFDB = x - \frac{xx}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \frac{x^5}{5}$, &c. and the Area $AFdb = x + \frac{xx}{2} + \frac{x^3}{3} + \frac{x^4}{4} + \frac{x^5}{5}$, &c. and the Sum $bdDB = 2x + \frac{2x^3}{3} + \frac{2}{5}x^5 + \frac{2}{7}x^7 + \frac{2}{9}x^9$, &c. Now if AB or Ab be $= \frac{1}{10} = x$; Cb being $= 0.9$. and $CB = 1.1$. by putting this Value of x in the Equations above, we shall have the Area $bdDB = 0.2006706954621511$ for the Terms of the Series will stand as you see in this Table.

0.2000000000000000 =	1st	Term of the Series
6666666666666 =	2d	
40000000000 =	3d	
285714286 =	4th	
2222222 =	5th	
18182 =	6th	
154 =	7th	
1 =	8th	
0.2006706954621511.		

If the Parts Ad, and AD of this Area be added separately, and the lesser DA be taken from the greater dA, we shall have $Ad - AD = x^2 + \frac{x^4}{2} + \frac{x^6}{3} + \frac{x^8}{4}$, &c. $=$ 0.0100503358535014. for the Terms reduced to Decimals will stand thus:

0.0100000000000000
500000000000
3333333333
25000000
200000
1667
14
0.0100503358535014

Now if this Difference of the Areas be added to and subtracted from

from their Sum before found, half the Aggregate 0.1053605156578263 will be the greater Area Ad, and half the Remainder 0.0953101798043248 will be the lesser Area AD.

By the same Tables these Areas AD and Ad will be obtain'd also when AB = Ab are supposed to be $\frac{1}{100}$ or CB = 1.01, and Cb = 0.99. if the Numbers are but duely transferred to lower Places, as

$$\begin{array}{r} 0.0200000000000000 \\ 6666666666 \\ 400000 \\ 28 \\ \hline \text{Sum } 0.0200006667066695 = bD \end{array}$$

$$\begin{array}{r} 0.0001000000000000 \\ 50000000 \\ 3333 \\ \hline 0.0001000050003333 = Ad - AD \end{array}$$

Half the Aggregate 0.0100503358535014 = Ad, and half the Remainder 0.0099503308531681 = AD.

And so putting AB = Ab = $\frac{1}{1000}$, or CB = 1.001, and Cb = 0.999, there will be obtain'd Ad = 0.0010005000333583 5, and AD = 0.0009995001333083 5.

After the same manner, if AB = Ab be = 0.2, or 0.02, or 0.002; these Areas will arise,
Ad = 0.2231435513142097, and AD = 0.1823215576939546, or Ad = 0.0202027073175194, and AD = 0.1098026272961797, or Ad = 0.002002, and AD = 0.001.

From these Areas thus found, others may be easily had from Addition and Subtraction only. For since $\frac{1.2}{0.8} \times \frac{1.2}{0.9} = 2$, the Sum of the Areas 0.6931471805599453 belonging to the Ratio's $\frac{1.2}{0.8}$ and $\frac{1.2}{0.9}$ (that is, insisting upon the Parts of the Absciss 1.2, 0.8, and 1.2, 0.9) will be the Area AFHG when CG is = 2. Also since $\frac{1.2}{0.8} \times 2 = 3$. the Sum 1.0986122886681097 of the Areas belonging to $\frac{1.2}{0.8}$ and 2, will be the Area AFGH, when CG = 3. Again since $\frac{2 \times 2}{0.8} = 5$. and $2 \times 5 = 10$; by a due Addition of Areas will be obtain'd 1.6093379124341004 = AFHG, when CG = 5. and 2.0325850929940457 = AFHG, when CG = 10; and since $10 \times 10 = 100$; and $10 \times 100 = 1000$; and $\sqrt{5 \times 10 \times 0.98} = 7$, and $10 \times 1.1 = 11$, and $\frac{1000 \times 1.091}{7 \times 11} = 13$, and $\frac{1000 \times 0.998}{2} = 499$; it is plain that the Area AFHG may be found by the Composition of the Areas found before when CG = 100, 1000, or any other of the Numbers above mentioned; and all these Areas are the Hyperbolic Logarithms of those several Numbers.

Having thus obtained the Hyperbolic Logarithms of the Numbers 10, 0.98, 0.99, 1.01, 1.02, which may be done in about an Hour or two's time. If the Logarithms of the four last of them be divided by the Hyperbolic Logarithm 2.3025850929940457 of 10, and the Index 2 be added, or which is the same thing, if it be multiplied by its Reciprocal 0.4342944819032518, we shall have the true Tabular Logarithms of 89, 99, 100, 101, 102. These are to be interpolated by ten Intervals, and then we shall have the Logarithms of all the Numbers between 980 and 1020; and all between

tween 980 and 1000, being again interpolated by ten Intervals, the Table will be as it were constructed; then from these we are to get the Logarithms of all the prime Numbers and their Multiples less than 100, which may be done by Addition and Subtraction only. For $\sqrt[10]{\frac{84\times1020}{9945}}=2$; $\sqrt[4]{\frac{8\times9963}{984}}=3$; $\frac{10}{2}=5$; $\sqrt{\frac{98}{2}}=7$; $\frac{99}{9}=11$; $\frac{1001}{7\times11}=13$; $\frac{102}{6}=17$; $\frac{988}{4\times13}=19$; $\frac{9936}{16\times27}=23$; $\frac{986}{2\times17}=29$; $\frac{992}{32}=31$; $\frac{999}{27}=37$; $\frac{984}{24}=41$; $\frac{989}{23}=43$; $\frac{987}{21}=47$; $\frac{9911}{11\times17}=53$; $\frac{9971}{13\times13}=59$; $\frac{9882}{2\times81}=61$; $\frac{9949}{3\times49}=67$; $\frac{994}{14}=71$; $\frac{9928}{8\times17}=73$; $\frac{9954}{7\times18}=79$; $\frac{996}{12}=83$; $\frac{9968}{7\times16}=98$; $\frac{9894}{6\times17}=97$; and thus having the Logarithms of all the Numbers less than 100, you have nothing to do but interpolate them several times thro' ten Intervals.

Now the void Places may be filled up by the following Theorem. Let n be a Number, whose Logarithm is wanted; let x be the Difference between that and the two nearest Numbers, equally distant on each side, whose Logarithms are already found, and let d be half the Difference of their Logarithms; then the requir'd Logarithm of the Number n will be had by adding $d+\frac{dx}{2n}+\frac{dx^3}{12n^3}$, &c. to the Logarithm of the lesser Number; for if the Numbers are represented by Cp, CG, CP, and the Ordinates ps, PQ be raised; if n be wrote for CG, and x for GP or Gp, the Area psQP or $\frac{2x}{n}+\frac{x^2}{2n^2}+\frac{x^3}{3n^3}$, &c. will be to the Area psHG, as the Difference between the Logarithms of the extreme Numbers, or $2d$, is to the Difference between the Logarithms of the lesser, and of the middle one, which therefore will be

$$\frac{\frac{dx}{n}+\frac{dx^2}{2n}+\frac{dx^3}{3n},\ \&c.}{\frac{x}{n}+\frac{x^3}{3n}+\frac{x^5}{5n},\ \&c.}$$

$=dx+\frac{dx}{2n}+\frac{dx^3}{12n}$, &c. the two first Terms $d+\frac{dx}{2n}$ of this Series, being sufficient for the Construction of a Canon of Logarithms, even to 14 Places of Figures, provided the Number whose Logarithm is to be found be less than 1000, which cannot be very troublesome, because x is either 1 or 2, yet it is not necessary to interpolate all the Places by help of this Rule, since the Logarithms of Numbers which are produced by the Multiplication or Division of the Number last found, may be obtain'd by the Numbers whose Logarithms were had before by the Addition or Subtraction of their Logarithms. Moreover, by the Difference of their Logarithms and by their second and third Differences, if necessary, the void Places may be supplied more expeditiously; the Rule aforegoing being to be applied only where the Con-

Continuation of ſome full Places is wanted, in order to obtain theſe Differences.

By the ſame Method Rules may be found for the Intercalation of Logarithms, when of three Numbers the Logarithm of the leſſer and of the middle Number are given, or of the middle Number and the greater; and this altho' the Numbers ſhould not be in Arithmetical Progreſſion. Alſo by purſuing the Steps of this Method, Rules may be eaſily diſcovered for the Conſtruction of the Tables of artificial Sines and Tangents, without the Help of the natural Tables. Thus far the great *Newton*, who ſays, in one of his Letters to Mr. *Leibnitz*, that he was ſo much delighted with the Conſtruction of Logarithms, at his firſt ſetting out in thoſe Studies, that he was aſhamed to tell to how many Places of Figures he had carried them at that time; and this was before the Year 1666, becauſe, (ſays he) the Plague made him lay aſide thoſe Studies, and think of other things.

Dr. *Keil*, in his *Little Tract of Logarithms*, at the end of his *Commandine's Euclid*, has given the following uſeful Series for finding the Logarithms of great Numbers. Let x be an odd Number, whoſe Logarithm is wanted; the Numbers $x-1$ and $x+1$ will be even, and ſo their Logarithms will be had, and the Difference of theſe Logarithms which call y; alſo there is given the Logarithm of a Number, which is a Geometrical Mean between $x-1$ and $x+1$, *viz.* equal to $\frac{1}{2}$ the Sum of the Logarithms. Then the Series $y \times \overline{\frac{1}{4x} + \frac{1}{24x^3} + \frac{7}{360x^5} + \frac{181}{15120x^7} + \frac{13}{25200x^9}}$, &c. will be equal to the Logarithm of the Number x. If the Number exceeds 1000, the firſt Term of the Series, *viz.* $\frac{7}{4x}$ is ſufficient to get the Logarithm to 13 or 14 Places of Figures, and the ſecond Term will give the Logarithm to 20 Places; and if x be greater than 10000, the firſt Term will exhibit the Logarithm to 18 Places of Figures. This Series is eaſily ſound out and deduced from the Conſideration of the Hyperbolic Spaces aforeſaid.

Mr. *Cotes*, in his *Harmon. Menſur.* at the Beginning ſays, if the Sum of two Numbers be z and their Difference x, and you ſuppoſe $M = 0{,}434294481903$, &c. *viz.* the Value of the Subtangent of the Logarithmic Curve, to which *Briggs*'s Logarithms are adapted, and you take $2M\frac{x}{z} = A$, $A\frac{xx}{zz} = B$, $B\frac{xx}{zz} = C$, $C\frac{xx}{zz} = D$, &c. then will the Logarithm of the Quotient of the Diviſion of the greater by the leſs be $= A + \frac{1}{3}B + \frac{1}{5}C + \frac{1}{7}D$, &c. So that to find the Logarithms of the prime Numbers 11, 13, 17, 19, 23, &c. you need but find the Product of the two Numbers deficient from either of them by 1, and exceeding it by 1, which will always exceed that Product by 1; then to the Logarithm of the Quotient of the Diviſion of that Square by the ſaid Product, found by the Rule but now expreſſed, add the Logarithm of that Product, which is always made up of the given Logarithms of the prime Numbers, being leſs than the given prime Number, and $\frac{1}{2}$ the Sum will be the Logarithm of the propoſed given Number.

Mr. *Mercator*'s *Logarithmotechnia*, ſet forth *An.* 1668, was the firſt public Treatiſe of the Conſtruction of Logarithms by the Hyperbola, that is, by

by help of infinite Series's, nearly expressing the Asymptotical Hyperbolic Spaces in Number. And after him Dr. *Gregory*, and others did the same thing; but no one has shewn how to perform the Business so perspicuous and elegant as Sir *Isaac*, as will easily appear upon comparing his Way above-mentioned with any other extant.—Dr. *Halley* too, (in *Trans. Philos.* N° 216.) has given their Nature and Construction (after a sort) without any mention of the Hyperbola; tho' it is evident, that all the while he had the Hyperbola and the Mensuration of the asymptotical Spaces under Consideration; but rather than expresly mention them, because he will not use Geometrical Figures in an Affair purely Arithmetical (as Mr. *Jones*, in his *Synopsis*, says) he perplexes and strains his Reader's Imagination with several almost unintelligible Ways of Expression; such as an *infinite Number n* of equal Ratio's or *Ratiunculæ, in a continued Scale of Proportions between the two Terms of any Ratio, as* 1 *and* $1+x$ or $\overline{1+x}^n$. Then $1+x$ *will be the first Mean or Root of the infinite Power* $\overline{1+x}^n$; and let x (says he) be a *Ratiuncula or Fluxion of the Ratio of* 1 *to* $1+x$. —*We may value Ratio's by the Number of Ratiunculæ contain'd in each.* —*An infinite Number of Means may be taken between the Terms of any Ratio, provided the same Proportion be every where observ'd.*—And those *Ratiunculæ* being hitherto *consider'd as having the same Magnitude in all Ratio's, the Logarithms of Ratio's are as the Number of Ratiunculæ contain'd between their Terms; and therefore the Logarithm of any Number is found by taking the Difference between Unity and the infinite Root of that Number*, &c. These and several other are the unintelligible, or at least obscure Expressions of the Doctor in his Logarithmical Doctrine; all which are entirely avoided, and the whole seems clear to any Arithmetician and Geometrician of the least Capacity from the Consideration of the Hyperbola, as above-mentioned.

Mr. *Cotes* too, at the Beginning of his *Harmon. Mensur.* has done this Business in imitation of Dr. *Halley*, altho' more short, yet with the same Obscurity: for I appeal to any one, even of his greatest Admirers, if they know what he would be at in his first Problem, *viz. to find the Measure of a Ratio* from the Terms of the Problem itself, (which should always be done) without having first known something of the matter from other Principles, as the Hyperbola, *&c.*

The Lord *Naper*, a *Scotch* Baron, was the first who found out Logarithms, having publish'd at *Edinburgh*, *Anno* 1614. Tables of Logarithmic Sines and Tangents for the Use of Trigonometry, in a Treatise, entitled *Canon Mirificum Logarithmorum*, computing them to every Degree and Minute, and making the Logarithm of the Radius *o*; so that as the Logarithm of the Sines increase, the Sines themselves decrease, and those of the Sines and Tangents greater than the Radius, are defective or less than *o*.

Altho' the Lord *Naper* is universally allow'd to be the first Inventor of the Logarithms, yet Mr. *Wolfe*, in his *Lexicon Mathem.* says, that *Kepler* in his *Rudolphin Tables* (chap. 3. p. 11.) mentions one *Job Byrge*, as having the Logarithms several Years before their Publication by the Lord *Naper*, and complains of him that he was *Hominem cunctatorem & secretorum suorum Custodem, qui Fœtum in Partu destituit, non ad Usus publicos educavit.* But to return to the Lord *Naper*; afterwards he thought of a more convenient

Form

Form of them; and having communicated his Design to Mr. *Henry Briggs*, the *Savilian* Professor of Geometry at *Oxford*; these two jointly undertook the bringing of Logarithms into a more convenient Form; but the Lord *Naper* dying before they had done, the whole Burthen remaining was laid upon Mr. *Briggs*'s Shoulders, who, with prodigious Labour, and great Skill, made a *Canon* of Logarithms, according to that new Form, for the Numbers from 1 to 20000, and from 90000 to 101000, to 14 Places of Figures, which was published at *London*, *Anno* 1624.

This *Canon* was again published in *Holland*, by *Adrian Vlaque*, *Anno* 1628. but filled up with the Logarithms of those Numbers omitted by Mr. *Briggs*; but these Logarithms are continued to but 10 Places of Figures. Mr. *Briggs* also computed the Logarithms of the Sines and Tangents to every Degree, and $\frac{1}{100}$ Part of a Degree to 15 Places of Figures, to which he subjoined the natural Sines, Tangents, and Secants, which he had before computed to 15 Places of Figures. And these Tables, together with a Treatise of their Construction and Use, was published at *London*, *Anno* 1633. after Mr. *Briggs*'s Death by *Henry Gelebrand*, under the Title of *Trigonometria Britannica*.— *Benjamin Ursinus*, in his *Trigonometry*, has given us a Canon of Logarithms to every 10 Seconds. And Mr. *Wolfe*, in his *Mathematical Lexicon*, says, that one *Van Loser* had computed them to every single Second; but his untimely Death prevented their Publication. Within this 60 Years there have been publish'd many compendious Tables of Logarithms of Numbers, Sines and Tangents, particularly at the Ends of Books of Navigation, consisting of only seven Places of Figures, where the Numbers to which the Logarithms are fitted, only run from 1 to 1000, which may be sufficient for many Cases.—But amongst those, *Sherwin*'s Tables of Logarithms, first publish'd at *London*, *Anno* 1705, are much the best. In these you have the Logarithms of all Numbers from 1 to 101000, consisting of seven Places of Figures, with the Differences of the Logarithms and the proportional Parts set against them, by means of which may be easily found the Logarithm of any Number from 1 to 10000000; so far, to wit, as these Logarithms are expressed by only seven Places of Figures. You have also the Logarithms of the Sines, Tangents, Secants, &c. to every Minute, and other useful Tables.

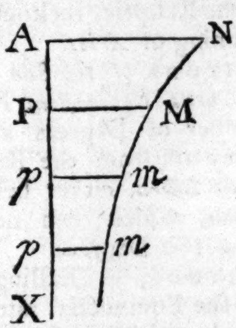
As the Hyperbolic Logarithm of 10 is to *Briggs*'s Logarithm of 10, so is the Hyperbolic Logarithm of any Number to *Briggs*'s Logarithm of that same Number; and if l be the Hyperbolic Logarithm of any Number greater than 1, then will $1 + \frac{l}{1} + \frac{ll}{2} - \frac{l^3}{6} + \frac{l^4}{24}$, &c. be that Number; but if less, it will be $1 - \frac{l}{1} + \frac{ll}{2} - \frac{l^3}{6} + \frac{l^4}{24}$, &c. These Series's are Sir *Isaac Newton*'s, and may be seen in his last Letter to Mr. *Leibnitz*.—If an artificial Tangent of any Arch a be t, and the artificial Secant s, and the whole Quadrant q, and r the Radius; then will s be $= \frac{a^2}{r} + \frac{a^4}{12r^3} + \frac{a^6}{45r^5} + \frac{17a^8}{2520r^7} + \frac{62a^{10}}{28350r^9}$, &c. and (suppose $2a - q = e$) $t = e + \frac{e^3}{6r} + \frac{e^5}{24r^4} + \frac{61e^7}{5040r^6} + \frac{277e^9}{72576r^8}$, &c. And if the artificial Secant of

$45°$ be $= s$, and $s + l$ be any artificial Secant, then will its Arch be $\frac{1}{2}q + l - \frac{l^2}{r} + \frac{4l^3}{3r^2} - \frac{7l^4}{3r^3} + \frac{14l^5}{3r^4} - \frac{452l^6}{45r^5}$, &c. and $2a - q = t - \frac{t^3}{6r} + \frac{t^5}{24r^4} - \frac{61t^7}{5040r^6} + \frac{277t^9}{72576r^8}$, &c. But here it must be observed that the artificial Radius is 0, and when q is greater than $2a$, or the artificial Secant of 24° is greater than the given Secant, the Signs are to be changed. These Series's are Dr. *James Gregory*'s, sent *Anno* 1670 to Mr. *Collins*.

LOGARITHMIC CURVE. If the Right Line AX be divided into any Number of equal Parts, and if in the Points of Division A, P, p, &c. be joined the Right Lines AN, PM, pm, &c. continually proportional and parallel; the Points N, M, m, &c. will be in the Curve called the *Logarithmic Curve*.

1. The Abscissa's AP, Ap, &c. are the Logarithms of the Ordinates PM, pm, &c.

2. Whence if AP $= x$, A$p = v$, PM $= y$, $pm = z$, and the Logarithms of y and $z = ly$, and lz;



then $x = ly$ and $v = lz$, and so $x : v :: ly : lz$, that is, the Denominators of the Ratio's of AN to PM, and AN to pm, are to one another as the Abscissa's AP, Ap.

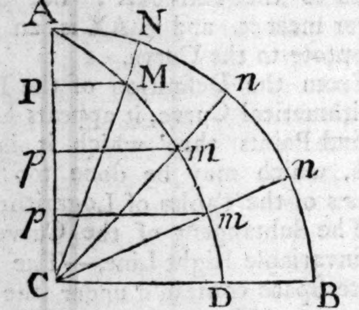
3. Whence there may be supposed infinite Kinds of Logarithmic Curves, if $x^m : v^m :: ly : lzl$; since the Ordinates pm continually decrease, while the Ratio of AN to pm continually increases with the Abscissa, the Curve continually accedes to the Axis AX; but will never meet it, and so AX is an Asymptote to the Curve.

From the Definition of the Logarithmetical Curve, it appears how to find Points thro' which it is to pass, which may be done too by means of the Tables of Logarithms. —The Subtangent of the Curve is an invariable Right Line.—The infinite Space contain'd under the Asymptote AX, the Curve NM infinitely continued towards M, and the Ordinate AN is equal to the Rectangle under AN and the Subtangent.— Any Part NM of the Curve is rectifiable by means of the Subtangent; for if PM be y, and the Subtangent a, the Fluxion of the Part NM will be $\frac{\dot{y}}{y}\sqrt{yy+aa}$. And the Fluent of this may be had by means of the Curve and Subtangent. See Mr. *Cotes*'s *Harmonia*. — Sir *Isaac Newton*, in the second Book of his *Princip.* demonstrates that a Projectile describes this Curve when moving in a Medium, whose Resistance is as the Velocity of a Body moving in it.— Concerning this Curve, see Mr. *Huygens*'s *Discours sur la Cause de Pesanteur*, pag. 176. and *Guido Grando*'s *Demonstratio Theorematum Huygenianorum circa Logisticam seu Logarithmicam Lineam*; as also Mr. *Bernoulli*'s Discourse in the *Acta Eruditorum*, *Anno* 1696, pag. 216.

LOGARITHMIC SPIRAL. If the Quadrant of a Circle ANB be divided into any Number of equal Parts in the Points N, n, n, &c. and from the Radii CN, Cn, Cn, &c.

be

be cut off CM, C*m*, C*m*, &c. continual Proportionals, the Points M, *m*, *m*, &c. will be in the Logarithmic Spiral. Whence the Arches AN, N*n*, *nn*, &c. are the Logarithms of the Ordinates CM, C*m*, &c. and there may be imagined an



infinite Number of different Curves of this kind.

Dr. *Halley*, in the *Philosophical Transactions*, has happily apply'd this Curve to the Division of the Meridian Line in *Mercator*'s Chart. See also Mr. *Cotes*'s *Harmonia*, *Guido Grando*'s *Demonstratio Theorematum Huygenianorum* ; the *Acta Eruditorum*, *An.* 1691. p. 282, and foll.

LOGISTICAL ARITHMETIC, was formerly the Arithmetic of sexagesimal Fractions, and used by Astronomers in their Calculations. I suppose it was so called from a *Greek* Treatise of one *Barlaamus*, a Monk, who wrote about Sexagesimal Multiplication very accurately, and entitled his Book *Logistice*. This Author *Vossius*, in his Book *de Scientiis Mathematicis*, places about the Year 1350, but mistakes it for a Treatise of Algebra.

Thus also *Shackerly*, in his *Tabulæ Britannicæ*, hath a Table of Logarithms adapted to Sexagesimal Fractions, which therefore he calls *Logistical Logarithms* ; and the expeditious Arithmetic of them, which is by this means obtained, and by which all the Trouble of Multiplication and Division is saved, he calls *Logistical Arithmetic*. Though some, by

LOGISTICS, will understand the first general Rules in Algebra, of Addition, Subtraction, &c.

LOGISTIC SPIRAL. See *Logarithmic Spiral.*

LOGISTICAL LINE, is that which is otherwise called the *Logarithmic Line*, where the Ordinates apply'd at equal Parts of the Axis are in geometrical Proportion.

LONGIMETRY, the Art of measuring Lengths or Distances, or to take the Distance of Trees, Steeples, or Towers, &c. either one, or many together ; for which purpose the *Theodolite* is reckoned to be the best Instrument.

LONGITUDE *of a Place*, is an Arch of the Equator intercepted between the Meridian of that Place, and the first Meridian ; or 'tis more truly the Difference, either East or West, between the Meridians of any two Places, counted on the Equator.

LONGITUDE *in the Heavens*, is an Arch of the Ecliptic, counted from the Beginning of *Aries*, to the Place where a Star's Circle of Longitude crosses the Ecliptic ; so that 'tis much the same as the Star's Place in the Ecliptic, reckoned from the Beginning of *Aries*.

LONGITUDE *of the Sun or Star from the next Equinoctial Point*, is the Number of Degrees and Minutes they are from the Beginning of *Aries* or *Libra*, either before or after them, which can never be more than 180 Degrees.

LONGITUDE, in Dialling. The Arch of the Equinoctial intercepted between the substilar Line of the Dial and the true Meridian, is called the *Plane's Difference of Longitude*.

LONGITUDE, in Navigation, is also the Distance of one Ship or Place, East or West from another, (counted

(counted in proper Degrees;) but of in Leagues or Miles, or Degrees of the Meridian, and not in thoſe proper to the Parallel of Latitude, it is commonly called *Departure*.

1. Several ways have been thought of to find the Longitude at Sea; the great *Deſideratum* of the Art of Navigation, for doing of which ample Rewards have been promiſed by ſeveral Nations; as by the Eclipſe of the Moon, her Tranſit over, or Appulſe to any eminent fixed Star; the Eclipſes of *Jupiter*'s *Satellites*, *&c.* which are all true in Theory, and may be practiſed aſhore with the greateſt exactneſs. For the time of any one of theſe Phænomena being truly calculated for the Meridian of *London* (ſuppoſe, or any other;) and Tables may be eaſily made of all of them, which the Navigator may carry to Sea with him. If then he could but obſerve the time of the Eclipſe or Tranſit at Sea with accurate exactneſs, the Difference of Time of the Eclipſe happening to him ſooner or later than at *London*, would give him the exact Longitude of the Place of the Ship, either Eaſt or Weſt from the Meridian of *London*: But the misfortune is, ſuch an Obſervation of an Eclipſe, and the exact Time of the Immerſion, or Emerſion of the deficient Body into, or out of the Shadow, is not to be made without Teleſcopes of ſuch a length, as the Motion of the Ship will not permit to be uſed at Sea: Tho' by the by, if Ships were ſent with good Inſtruments, and Men that know how to uſe them, to do this at all the Capes and Headlands of the World, it would be a thing of the greateſt uſe; and by ſettling the Longitude of all thoſe Places, would cut all long Voyages into many ſhort ones, and afford means of continually rectifying the Dead reckoning at Sea. But to return.

2. Others being fully ſatisfied of the Impracticableneſs of the Method of Eclipſes for finding the Longitude at Sea, have thought of doing it by a Clock or Watch: Which indeed, if it could be made to go right all the time of a long Voyage, would give the Longitude at any time, when the true Hour of the Day or Night could be had under any Meridian, or in any Place of the Earth: For the Clock going true for the Meridian it was firſt ſet at, will ſhew the true Hour of the Day or Night under any Meridian, or in any Place of the Earth; and then the true Hour being found by the Sun or Stars in the Place where the Ship is, the Difference between that and the Clock's Hour will be the Difference of the Meridian in Time, or Longitude in Degrees.

3. But it is not eaſy to make ſuch a Movement, as will keep going in all Weathers, and all Climates truely, eſpecially in ſome of the Southern ones, where the Dews are ſo great as to ruſt the Parts of it; and ſo retard, if not ſtop its Motion.

4. Another Inconveniency is, that in different Latitudes the Hours ſhewn by the Clock, will be different from thoſe ſhewn by it for the Latitude to which it is fitted; as a Clock at *London* made to ſhew the Time there, when carried under the Equinoctial, will go too ſlow by 2 or 3 Minutes, and the Law of the Retardation as you go Southwards is not yet well known.

5. Notwithſtanding this, Mr. *Huygens* in his excellent *Horologium Oſcillatorium*, mentions two Clocks that were formerly made by his Directions there laid down, being carried to Sea in an *Engliſh* Ship, in company with three other Ships, which very much aſſiſted the Captain to judge of the true Place of the Ship: For the Captain ſaid, when

when they had sailed from the Coast of *Guinea* to the Island of *St. Thomas*, under the Equinoctial Circle, and there set the Clocks to the Sun; they sailed Westwardly about 70 Miles, and then directed their Course towards the *African* Shore; and when they continued on upon a Course for about 2 or 300 Miles, the Captains of the rest of the Ships fearing they should want Water before they could arrive at the Coast of *Africa*, would have them go to get Water at the *American* Islands, called the *Caribbes*; and a Consultation being held thereupon, the Journals and Reckonings of each Ship were produced, all which differ'd from the Captain's, who had the Clocks aboard; one 120 Miles, another 100, and the third still more. But the Captain himself said, he gathered from his Clocks, that they were not more than above 30 Miles from one of the *African* Islands, call'd *del Fuego*, nigh to the Coast of *Africa*, and might arrive at the same the next day. And ordering them to direct their Course accordingly, they saw the said Island the next day at Noon, and in a few Hours after arrived at the same.

Mr. *Huygens* in the same Book, says, that afterwards by the Command of *Lewis* the XIVth, the *French* and *Dutch* made various Experiments with his Clocks; but with various Events, which he attributed often more to the Negligence and Unskilfulness of the Persons to whose Care they were committed, than to the Faults in the Clocks themselves. See more, pag. 17. *Horol. Oscillat.*

6. But the most ingenious and best Clock that ever was, or perhaps ever will be made for this purpose, is that of Mr. *Harrison* of *Leather-Lane*, *London*, as I have been informed by Persons, whom I take to be very good Judges; and which has been approved of and recommended by Mr. *George Graham*, Dr. *Smith*, and Dr. *Barker*, as I have been informed.

LOWER FLANK, or RETIRED FLANK. See *Flank*, a Term in Fortification.

LOXODROMIQUES, is the Art or Way of oblique Sailing by the Rhumb, which always makes an equal Angle with every Meridian, *i.e.* when you sail neither directly under the Equator, nor under one and the same Meridian, but obliquely or a-cross them. Hence the Table of Rhumbs, or the Traverse-Table of Miles, with the Difference of Longitudes and Latitudes, by which the Sailor may practically find his Course, Distance, Latitude, or Longitude, is by some called by this Name of *Loxodromiques*; and such Tables as serve truly and expeditiously to find the several Requisites, or to resolve the Cases of Sailing, are called *Loxodromical Tables*.

LUCIDA CORONA, a fixed Star of the second Magnitude, in the Northern Garland, whose Longitude is 217 Deg. 38 Min. Latitude 44 Deg. 23 Min. Right Ascension 230 Deg. 12 Min.

LUCIDA HYDRA. See *Cor Hydræ*.

LUCIDA LYRA, a bright Star of the first Magnitude, in the Constellation *Lyra*, whose Longitude is 10 Deg. 43 Min. Latitude 61 Deg. 47 Min. Right Ascension 276 Deg. 27 Min. And Declination 38 Deg. 30 Min.

LUMINARIES, the Sun and Moon are so called by way of Eminence; for their extraordinary Lustre, and the great Quantity of Light that they afford us.

LUNAR CYCLE. See *Cycle of the Moon*.

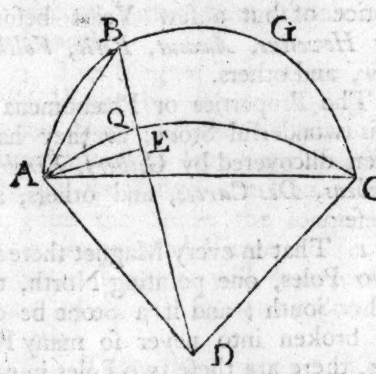
LUNARY MONTHS, are either Periodical, Synodical, or Illuminative.

tive. Which see in their proper Places.

Lunation *of the Moon*, is the Time between one New Moon and another; and this is greater than the Periodical Month by two Days and five Hours; and is called the *Synodical Month*, consisting of 29 Days, 12 Hours, and three Quarters of an Hour.

Lunes, *or* Lunulæ, in Geometry, are Spaces contain'd under a Quadrant of a Circle, and a Semicircle; being called thus, because they represent the Figure of the Moon, when less than half full; as the Space A B G C is the Lune.

If the Line A B is drawn, as also the Line A E, at Right Angles to B D; I say the Triangle A B E is equal to the Part A B Q of the Lune, and so the whose Lune is equal to the Triangle A D C.



Lunettes, in Fortification, are Envelopes, Counter-guards, or Mounts of Earth cast up before the Curtain, about five Fathom in breadth, whereof the Parapet takes up three. They are usually made in Ditches full of Water, and serve to the same purpose as Falsebrayes. These Lunettes are composed of two Faces, which form a re-entring Angle; and their Platform being only twelve Foot wide, is a little raised above the Level of the Water, and hath a Parapet three Fathom thick.

Lupus, a Southern Constellation, consisting of two Stars.

Lyra, the Harp, a Constellation in the Northern Hemisphere, consisting of 13 Stars.

M.

Machina Boyleiana, Mr. *Boyle*'s Air-Pump.

Machine, *or* Engine, in Mechanics, is whatsoever hath Force sufficient either to raise or stop the Motion of a Body. These Machines are either Simple or Compound.

Simple Machines are commonly reckoned to be six in Number, *viz.* the Ballance, Leaver, Pulley, Wheel, Wedge, and Screw. To these might be added the inclined Plane; since 'tis certain that the heaviest Bodies may be lifted up by the means thereof, which otherwise could scarce be moved.

Compound Machines or Engines are innumerable, in regard that they may be made out of the Simple, almost after an infinite Manner.

Madrier, in Fortification, is a thick Plank, armed with Plates of Iron, and having a Concavity sufficient to receive the Mouth of the Petard when charged, with which it is apply'd against a Gate, or any thing else that you design to break down. This Term is also appropriated to certain flat Beams, which are fixed to the Bottom of a Moat, to support a Wall. There are also Madriers lined with Tin, which are covered with Earth, to serve as a Defence against artificial Fires.

Magic Square, is when Numbers in Arithmetic Progression are disposed into such parallel and equal ranks, as that the Sums of each Row, as

as well diagonally as laterally, ſhall be equal.

Thus theſe nine Numbers, 2, 3, 4, 5, 6, 7, 8, 9, and 10, being diſ-

5	10	3
4	6	8
9	2	7

poſed into this ſquare Form, they do every way directly and diagonally make the ſame Sum: As likewiſe thoſe 49 Numbers;

30	39	48	1	10	19	28
38	47	7	9	18	27	29
46	6	8	17	26	35	37
5	14	16	25	34	36	45
13	15	24	33	42	44	4
21	23	32	41	43	3	12
22	31	40	49	2	11	20

Magic Lanthorn, a little Optic Machine, by the means of which are repreſented on a Wall, in the dark, many Phantaſms and terrible Apparitions, which are taken for the Effect of Magic, by thoſe that are ignorant of the Secret.

This Machine is compoſed of a concave Speculum from one Foot to four Inches Diameter, reflecting the Light of a Candle, which paſſeth through a little Hole of a Tube, at whoſe End there is faſten'd another double Convex-Glaſs of about three Inches Focus; between theſe two are ſucceſſively placed many ſmall Glaſſes, painted with different Figures, of which the moſt formidable are always choſen, and ſuch as are moſt capable of terrifying the Spectators; ſo that all theſe Figures may be repreſented at large on the oppoſite Wall.

Magnet, *or* Load-Stone, is a Foſſile approaching to the Nature of Iron-Ore, and endowed with the Property of attracting of Iron, and of both pointing itſelf, and alſo enabling a Needle touched upon it, and then poiſed, to point towards the Poles of the World.

Sturmius, in his *Epiſtola Invitatoria Dat. Altrof.* 1682, obſerves, that the attractive Quality of the Magnet hath been taken Notice of beyond all Hiſtory; but that it was our Countryman *Roger Bacon*, who firſt diſcovered the Verticity of it, or its Property of pointing towards the Pole; and this about 400 Years ſince. The *Italians* firſt diſcovered, that it would communicate this Virtue to Steel or Iron. The various Declination of the Needle, under different Meridians, was firſt diſcovered by *Sebaſtian Cabott*; and its Inclination to the nearer Pole by our Countryman *Robert Noman*. The Variation of the Declination, ſo that 'tis not always the ſame in one and the ſame Place, he obſerves, was taken notice of but a few Years before, by *Hevelius*, *Auzout*, *Petit*, *Volckamer*, and others.

The Properties or Phænomena of this wonderful Stone, as they have been diſcovered by *Gilbert*, *Kircher*, *Cabeus*, *Des Cartes*, and others, are theſe:

1. That in every Magnet there are two Poles, one pointing North, the other South; and if a Stone be cut or broken into never ſo many Pieces, there are theſe two Poles in each Piece.

2. That theſe Poles in divers Parts of the Globe, are diverſely inclined towards the Earth's Centre.

3. That theſe Poles, tho' contrary to one another, do help mutually toward the Magnet's Attraction and Suſpenſion of Iron.

4. If two Magnets are ſpherical, one will turn or conform itſelf to the other, ſo as either of them would do to the Earth; and that after they have ſo conformed or turned themſelves,

ſelves, they endeavour to approach to join each other; but if placed in a contrary Poſition, they avoid each other.

5. If a Magnet be cut through the Axis, the Parts or Segments of the Stone, which before were joined, will now avoid and fly each other.

6. If the Magnet be cut by a Section perpendicular to its Axis, the two Points which before were conjoined, will become contrary Poles, one in one, the other in the other Segment.

7. Iron receives Virtue from the Magnet by Application to it, or barely from an Approach near it, though it doth not touch it; and the Iron receives this Virtue variouſly, according to the Parts of the Stone 'tis made to touch, or made to approach to.

8. If any oblong Piece of Iron be any how applied to the Stone, it receives Virtue from it only as to its Length.

9. The Magnet loſes none of its own Virtue by communicating any to the Iron, and this Virtue it can communicate to Iron very ſpeedily; though the longer the Iron touches or joins the Stone, the longer will its communicated Virtue hold; and a better Magnet will communicate more of it, and ſooner than one not ſo good.

10. That Steel receives Virtue from the Magnet better than Iron.

11. A Needle touched by a Magnet, will turn its Ends the ſame way towards the Poles of the World, as the Magnet will do.

12. That neither Loadſtone nor Needles touched by it, do conform their Poles exactly to thoſe of the World; but have uſually ſome Variation from them; and this Variation is different in divers Places, and at divers Times in the ſame Place.

13. That a Loadſtone will take up much more Iron when armed or capped, than it can alone; and that though an Iron Ring or Key be ſuſpended by the Loadſtone, yet the Magnetical Particles do not hinder that Ring or Key from tutning round any way, either to the Right or Left.

14. That the Force of a Loadſtone may be variouſly increaſed or leſſened by the various Application of Iron, or another Loadſtohe to it.

15. That a ſtrong Magnet, at the leaſt Diſtance from a leſſer or a weaker, cannot draw to it a Piece of Iron adhering actually to ſuch leſſer or weaker Stone; but if it comes to touch it, it can draw it from the other: But a weaker Magnet, or even a little Piece of Iron, can draw away or ſeparate a Piece of Iron, contiguous to a greater or ſtronger Loadſtone.

16. That in our North Parts of the World, the South Pole of a Loadſtone will raiſe up more Iron than the North Pole.

17. That a Plate of Iron only, but no other Body interpoſed, can impede the Operation of the Loadſtone, either as to its attractive or directive Quality. Mr. *Boyle* found it true in Glaſſes ſealed hermetically; and Glaſs is a Body as impervious as moſt are, to any Effluvia.

18. That the Power or Virtue of a Loadſtoue may be impaired by lying long in a wrong Poſture, as alſo by Ruſt, Wet, &c. and may be quite deſtroyed by Fire.

The Orb of the Activity of Magnets is larger or leſs at different times; which is confirmed by what is found in fact to be true of our noble Loadſtone, which is kept in the Repoſitory of the *Royal Society*; for that will keep a Key, or other Piece of Iron, ſuſpended to another, ſometimes at the Diſtance of eight or ten Foot from it; but at other times, not beyond the Diſtance of four Foot.

Magnetical Amplitude, is an Arch of the Horizon, contained between the Sun at his rising or setting, and the East and West Point of the Compass; or it is the different rising or setting of the Sun from the East and West Points of the Compass; and is found by observing the Sun at his rising or setting, by an amplitude Compass.

Magnetism, *or* Magnetical Attraction, is the Virtue or Power that the Loadstone has of drawing Iron to it.

Magnetical Azimuth, is an Arch of the Horizon, contained between the Sun's Azimuth Circle, and the Magnetical Meridian; or it is the apparent Distance of the Sun from the North or South Point of the Compass; and may be found by observing the Sun with an Azimuth Compass, when he is about ten or fifteen Degrees high, either in the Forenoon or Afternoon.

Magnetical Meridian. See *Meridian*.

Magnetical Needle, is the touched Needle of the Compass.

Magnify, is a Word used chiefly with regard to Microscopes, being only the bringing the Object nearer to the Eyes, and letting some Parts of it be seen, which before were not discoverable by the bare Eye.

Magnitude. The same as Bigness or Greatness.

Mantelets, in Fortification, are a kind of moveable Penthouses, and are made of Pieces of Timber sawed into Planks; which being about three Inches thick, are nailed one over another to the height of almost six Foot. They are generally cased with Tin, and set upon little Wheels; so that in a Siege they may be driven before the Pioneers, and serve as Blinds to shelter them from the Enemy's Small-shot. There are also other Sorts of Mantelets, covered on the Top, whereof the Miners make use, to approach the Walls of a Town or Castle.

Map, is a Description of the Earth, or some particular Part thereof, projected upon a plain Superficies; describing the Form of Countries, Rivers, Situations of Cities, Hills, Woods, and other Remarks.

Anaximander the Scholar of *Thales*, about 400 Years before Christ, is said to have been the first Inventor of Geographical Tables, or Maps; and the *Peutingerian* Tables, published by *Cornelius Peutinger* of *Ausburgh*, contain an Itinerary of the whole *Roman* Empire; all Places, except Seas, Woods and Deserts, being put down according to their measured Distances, but without any mention of Latitude, Longitude, or Bearing.

Ptolemy of *Alexandria*, who lived about the 144th Year of Christ, invented Meridians and Parallels, the better to define and determine the Situations of Places, brought Maps to a much greater Degree of Perfection than before. But *Ptolemy* himself owns, *that those Maps* going by his Name, were copied from others that were made by *Marinus Tyrus*, &c. with some Improvements of his own added. But from his Time till about the 14th Century, whilst Geography lay dead, no new Maps were published. *Mercator* was the first of Note, and next to him *Ortelius*, who undertook to make a new Set of Maps, with the modern Divisions of Countries and Names of Places; for want of which, *Ptolemy*'s were grown almost useless. After him many others published Maps, but for the most part were mere Copies of his.—Towards the middle of the last Century, Mr. *Bleau* in *Holland*, and Mr. *Sanson* in *France*, published new Sets of Maps, with many Improvements from the Travellers of those Times; which were afterwards copied, with very little

little Variation, by the *English*, *French* and *Dutch*; the best of these being those of Mr. *De Wit*, and *Vischer*.—Maps being by so many blind Copiers likely to fall into much Obscurity and Error, Mr. *De Lisle*, an ingenious *French* Geographer, made a compleat Set of Maps, both of the old and new Geography, corrected and improv'd from the Surveys several *European* Nations had made of their respective Countries, the Observations of the best Travellers in all Languages, and the Journals of the Royal Societies of *London* and *Paris*.—Concerning Maps, see *Varenius*'s *Geogr. Gener.* lib. 3. cap. 3. Prop. 4. p. m. 445. and foll. *Fournier*'s *Hydrogr.* lib. 4 c. 24. and foll. f. 667. *Wolfius*'s *Elem. Hydrogr.* c. 9. *John Newton*'s *Idea of Navigation*, and *Mead*'s *Construction of Globes and Maps*.

MARINE BAROMETER. See *Barometer*.

MARS, the Name of one of the Planets which moves round the Sun in an Orbit between that of the Earth and *Jupiter*.

1. The mean Distance of *Mars* ♂ from the Sun is 1524 such Parts, of which the Earth's is 1000, its Excentricity 141, the Inclination of its Orbit 1 Deg. 52 Min. Its Periodical Time 686 Days, 23 Hours. Its Revolution about its Axis is performed in 24 Hours, 40 Min.

2. This Planet (as well as the rest) borrows its Light from the Sun; and has its Increase and Decrease of Light like the Moon; and it may be seen almost bissected when in his Quadratures with the Sun, or in his Perigæon, but never corniculated or falcated, as the other Inferiors.

3. *March* 10. 1665. Dr. *Hook* observed this Planet, with a 36 Foot Tube, and saw its Body as large very near as the Moon at Full; and in it he observed several Spots, and particularly a triangular one; which having a Motion, he concluded the Planet to have a turbinated Motion round its Centre.

4. In the Year 1666, *February* the 6th in the Morning, Mr. *Cassini*, with a 16 Foot Telescope, observed two dark Spots in the first Face of *Mars*, moving from Eleven at Night until Break of Day.

5. *February* the 24th, in the Evening, he saw two other Spots in the other Face of this Planet, like those of the first, but much bigger; and continuing the Observations, he found the Spots of those two Faces to turn by a little and a little from East to West, and so return at the Space of 24 Hours, 40 Minutes to the same Situation, wherein they were seen at first.

6. Whence he concluded, that the Revolution of this Planet round its Axis, is performed in the Space of 24 Hours, 40 Minutes, or thereabouts.

7. The Magnitude of *Mars* to the Magnitude of the Earth, is as 216 to 343, and its apparent Diameter, according to Mr. *Flamstead* and *Cassini*, is 35.

8. That *Mars* hath an Atmosphere, like ours, is argued from the Phænomena of the fixed Stars appearing obscured, and, as it were, extinct, when they are seen just by the Body of *Mars*; and if so, a Spectator in *Mars* will hardly ever see *Mercury*, unless it may be seen in the Sun, when that Planet passes over his Disk like a Spot, as he doth sometimes to us.

MATHEMATICS, originally signify any Discipline or Learning, (*Mathesis*:) But now, 'tis properly that Science which teaches or contemplates whatever is capable of

being numbered or measured, as it is computable or measurable.

And the Part of Mathematics which relates to Number only, is called *Arithmetic*; that which relates to Measure in general, whether Length, Breadth, Motion, Force, *&c.* is called *Geometry*.

MATHEMATICS may be reckoned either,

1. Pure, simple, or abstracted, which considers abstracted Quantity, without any relation to Matter, or sensible Objects. Or,

2. Mix'd Mathematics, which is interwoven every where with physical Considerations.

MATHEMATICS also are divided into,

1. Speculative, which proposes only the simple Knowledge of the thing proposed, and the bare Contemplation of Truth or Falshood. And,

2. Practical, which teaches how to demonstrate something useful, or to perform something that shall be proposed for the Benefit and Advantage of Mankind.

Aristotle (in 1. *Met.* 5.) says, the *Pythagoreans* were the first amongst the *Greeks* that meddled with Mathematics, and divided them into four Parts, two Pure and Primary, *viz.* Arithmetic and Geometry; and the other two Mix'd and Secondary, as Music and Astronomy. —*Plato* (in 7. *de Rep.*) divides them into five Parts, Arithmetic, Geometry, Stereometry, Musick and Astronomy; and *Aristotle* himself added to them, Optics, Mechanics, and Geodesia; and *Proclus* (in his Comment upon *Euclid*'s first Book) says, that *Geminus*, who liv'd about the Time of *Pompey* the Great, divided Mathematics into Arithmetic, Geometry, Geodesy, Logistics, Optics, Canonics, or Harmonics, Mechanics, and Astrology. And this Division has been kept to by many of the more modern Mathematicians, altho' some banish from hence Geodesy and Logistics.

That the *Romans*, especially in the Times of their Emperors, were not Lovers, or even had a just Notion and valuable Opinion of Mathematics, abundantly appears from several of their Writers, reckoning the Mathematicians amongst Conjurers and Soothsayers. *Tacitus* (in 1. *Annal.*) calls Mathematicians a Brood of Fellows treacherous to those above them, false to those who put their trust in them, which (says he) will be always prohibited, and always retain'd in our City. *Seneca* (in his Play of *Claudius*) says, it is manifest the Mathematicians sometimes speak Truth; alluding to the thousand lying Predictions of the Death of *Claudius*, concerning which at last they spoke true. *Julius Paulus lib.* 5. *cap.* 21. *Sententiarum*, ranks Mathematicians amongst cunning Men and Astrologers *Dio* (in *lib.* 49. *Historiarum*) says, that *Agrippa* caused the Astrologers and Magi to be removed from the City. *Tacitus*, that in the Reigns of *Tiberius* and *Claudian*, the Senate pass'd a Decree for banishing the Mathematicians and Conjurers out of *Italy*. In the *Cod. Justinian.* (*lib.* 9. *titulo* 18) it is said, that the Art of Geometry is necessary to be learn'd and useful to the Public; but the mathematical Art is damnable, and ought to be forbid entirely. These and many other Instances of the vile abuse of the word Mathematics amongst those degenerating Ages of the *Romans*, are to be found in *Tacitus*, *Suetonius*, *&c.* But during the Time of the *Roman* Commonwealth, when learning flourished more amongst them, the Mathematicians were in esteem, and distinguished from Fortunetellers; for

Cicero

Cicero (in *Lib. de Divin.*) ſays, Do you imagine that Conjurers can reſolve whether the Sun be greater than the Earth, or ſo great as it appears; or whether the Moon has an inherent Light, or borrows it from the Sun? To tell theſe things, ſays he, belongs to the Mathematicians, and not the Conjurers.

No body (that I know) has ſo elegantly ſet forth and deſcrib'd the Uſes of Mathematics, as the great Dr. *Barrow*, in his Prefatory Oration upon his Admittance into the Profeſſorſhip at *Cambridge*; his Words (tranſlated) are, 'The Mathematics (ſays he) effectually exerciſes, not vainly deludes, nor vexatiouſly torments ſtudious Minds with obſcure Subtilties, perplex'd Difficulties, or contentious Diſquiſitions; which conquers without Oppoſition, triumphs without Pomp, compels without Force, and rules abſolutely without the Loſs of Liberty; which does not privately over-reach a weak Faith, but openly aſſaults an armed Reaſon, obtains a total Victory, and puts on inevitable Chains; whoſe Words are ſo many Oracles, and Works as many Miracles; which blabs out nothing raſhly, nor deſigns any thing from the purpoſe. But plainly demonſtrates and readily performs all things within its compaſs; which obtrudes no falſe Science, but the very Science itſelf, the Mind firmly adhering to it, as ſoon as poſſeſs'd of it, and can never after of its own accord deſert it, or be deprived of it by any Force of others: Laſtly, (ſays he) the Mathematics which depend upon Principles clear to the Mind, and agreeable to Experience, which draws certain Concluſions, inſtructs by profitable Rules, unfolds pleaſant Queſtions, and produces wonderful Effects; which is the fruitful Parent of, I had almoſt ſaid, all Arts, the unſhaken Foundation of Sciences, and the plentiful Fountain of Advantage to human Affairs. In which laſt reſpect, we may be ſaid to receive from Mathematics, the principal Delights of Life, Securities of Health, Increaſe of Fortune, and Conveniences of Labour. That we dwell elegantly and commodiouſly, build decent Houſes for our ſelves, erect ſtately Temples to God, and leave wonderful Monuments to Poſterity: That we are protected by thoſe Rampires from the Incurſions of the Enemy, rightly uſe Arms, and artfully manage War; ſkilfully range an Army, that we have ſafe Traffick through the deceitful Billows, paſs in a direct Road thro' the trackleſs Ways of the Sea, and arrive at the deſign'd Ports, by the uncertain Impulſe of the Winds: That we rightly caſt up our Accounts, do Buſineſs expeditiouſly, diſpoſe, tabulate, and calculate ſcatter'd Ranks of Numbers, and eaſily compute them, tho'ugh expreſſive of huge Heaps of Sand, nay immenſe Hills of Atoms: That we make pacifick Separations of the Bounds of Lands, examine the Momentums of Weights in an equal Balance, and diſtribute every one his own by a juſt Meaſure; that with a light Touch we thruſt forwards Bodies which way we will, and ſtop a huge Reſiſtance with a very ſmall Force; that we accurately delineate the Face of this earthly Orb, and ſubject the Oeconomy of the Univerſe to our Sight: That we aptly digeſt the flowing Series of Time, diſtinguiſh what is acted by due Intervals, rightly account and diſcern the various Returns of the Seaſons,

'Seasons, the stated Periods of the 'Years and Months, the alternate 'Increasements of Days and Nights, 'the doubtful Limits of Light and 'Shadow, and the exact difference 'of Hours and Minutes; that we 'derive the solar Virtue of the 'Sun's Rays to our Uses, infinitely 'extend the Sphere of Sight, en'large the near Appearances of 'Things, bring remote Things near, 'discover hidden Things, trace 'Nature out of her Concealments, 'and unfold her dark Myste'ries: That we delight our Eyes 'with beautiful Images, cunningly 'imitate the Devices and pourtray 'the Works of Nature. Imitate, 'did I say? nay excel; while we 'form to ourselves things not in 'being, exhibit things absent, and 'represent things past; that we re'create our Minds, and delight our 'Ears with melodious Sounds, at'temperate the unconstant Undula'tions of the Air to musical Tunes, 'add a pleasant Voice to a sapless 'Log, and draw a sweet Eloquence 'from a rigid Metal; celebrate our 'Maker with a harmonious Praise, 'and not unaptly imitate the bles'sed Choirs of Heaven: That we 'approach and examine the inac'cessible Seats of the Clouds, distant 'Tracts of Land, unfrequented Paths 'of the Sea; lofty Tops of Moun'tains, low Bottoms of Valleys, and 'deep Gulphs of the Ocean; that 'we scale the etherial Towers, 'freely range through the celestial 'Fields, measure the Magnitudes, 'and determine the Interstices of 'the Stars, prescribe inviolable 'Laws to the Heavens themselves, 'and contain the wandering Cir'cuit of the Stars within strict 'Bounds: Lastly, that we compre'hend the huge Fabric of the Uni'verse, admire and contemplate the 'wonderful Beauty of the Divine 'Workmanship, and so learn the 'incredible Force and Sagacity of 'our own Minds by certain Expe'riments, as to acknowledge the 'Blessings of Heaven with a pious 'Affection.

'I omit the advantageous Spur 'to our Reason, which accrues 'from this mathematical Exercise, 'both effectually to turn aside the 'Strokes of true Arguments, and 'warily decline the Blows of false 'ones; to dispute strenuously, as well 'as judge solidly, with a readiness 'of Invention, a justness of Me'thod, and clearness of Expression.

'In like manner, these Disci'plines do inure and corroborate 'the Mind to a constant Diligence 'in Study, to undergo the Trouble 'of an attentive Meditation, and 'cheerfully contend with such Dif'ficulties as lie in the way; they 'wholly deliver us from a credu'lous Simplicity, most strongly for'tify us against the Vanity of 'Scepticism, effectually restrain us 'from a rash Presumption, most 'easily incline us to a due Assent, 'perfectly subject us to the go'vernment of right Reason, and 'inspire us to wrestle against the 'unjust Tyranny of false Prejudices. 'If the Fancy be unstable and fluc'tuating, it is as it were poised by 'this Ballast, and steadied by this 'Anchor; if the Wit be blunt, it 'is sharpen'd upon this Whetstone; 'if luxuriant, it is pared by this 'Knife; if headstrong, it is restrain'd 'by this Bridle; and if dull, it is 'roused by this Spur. The Steps 'are guided by no Lamp more 'clearly thro' the dark Mazes of 'Nature, by no Thread more 'surely thro' the intricate Turn'ings of the Labyrinths of Philo'sophy; nor, lastly, is the bottom 'of Truth sounded more happily 'by any other Line. I will not 'mention with how plentiful a Stock 'of Knowledge the Mind is fur-

nished

'nished from these, with what 'wholesome Food it is nourished, 'and what sincere Pleasure it enjoys. But if I speak further, I 'shall neither be the only Person, 'nor the first who affirm it, that 'while the Mind is abstracted and 'elevated from sensible Matter, 'distinctly views pure Forms, conceives the Beauty of Ideas, and 'investigates the Harmony of Proportions; the Manners themselves 'are sensibly corrected and improved, the Affection composed 'and rectified, the Fancy calmed 'and settled, and the Understanding 'raised and excited to more Divine 'Contemplations. All which I 'might defend by the Authority, 'and confirm by the Suffrages of 'the greatest Philosophers, *&c.*' Thus far the great Dr. *Barrow*.

The first who published a Mathematical Cursus, was *Peter Herigon*, Anno 1644.—After him came out *Caspar Schottus*'s, then Sir *Jonas Moore*'s *New System of Mathematics*. —*Dechales*'s *Cursus*, or *Mundum Mathematicum*.— *Leybourn*'s *Course of Mathematics*.—*De Graaf*'s *Cursus*, in *Dutch*.—*Ozanam*'s *Cours de Mathematique*.—*Taylor*'s *Treasure of the Mathematics*.—*Wolfius*'s *Elementa Matheseos Universal*. —*Sturmy*'s *Mathesis Juvenilis*.—*Jones*'s *Synopsis*, &c.

MATTER, *or* BODY, is an impenetrable, divisible, and passive Substance, extending into Length, Breadth, and Thickness. This, when considered in general, remains the same in all the various Motions, Configurations, and Changes of Natural Bodies, being capable of putting on all manner of Forms, and of moving according to all manner of Directions and Degrees of Velocity; the Quantity of Matter in any Body, is its Measure arising from the joint Consideration of the Magnitude and Density of that Body; as if any Body be twice as dense as another, and takes up twice the Space, 'twill be four times as great. This Quantity of Matter is best discoverable by Weight, to which 'tis always proportionable; as Sir *Isaac Newton*, by most accurate Observations on Pendulums, found true by Experience.

MAXIMIS *and* MINIMIS. The Mathematicians call that Method whereby a Problem is resolved, which requires the greatest or least Quantity attainable in that case, *Methodus de Maximis & Minimis*.

1. If any flowing Quantity in an Equation proposed be required to be determined to any extreme Value:

2. Having put the Equation into Fluxions, let the Fluxion of that Quantity (whose Extreme Value is sought) be supposed $=o$; by which means all those Members of the Equation in which it is found, will vanish, and the remaining ones will give the Determination of the *Maximum* or *Minimum* desired.

MEAN ANOMALY, See *Anomaly*.

MEAN CONJUNCTION, is when the Mean Place of the Sun is the same with the Mean Place of the Moon in the Ecliptic. And a

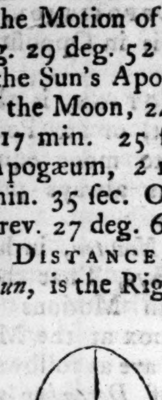
MEAN OPPOSITION, is when the former is in Opposition to the latter.

MEAN MOTION, is that wherewith a Planet, or any Point or Line is supposed to move equally in its Orbit, and is always proportional to the Time.

Sir *Isaac Newton*, in his *Theory of the Moon*, says, That the Sun and Moon's mean Motions from the vernal Equinox at the Meridian of *Greenwich*, are as follows, *viz.* the last Day of *December* 1680, *Old Style*, at Noon, the Sun's mean Motion 9 sig. 20 deg. 34 min. 46 sec. That of the Sun's Apogæum 3 sig. 7. deg. 23 min. 30 sec. The Moon's mean Motion 6 sig. 1 deg. 45 min.

45 sec. That of the Moon's Apogæum 8 sig. 4 deg. 28 min. 5 sec. That of the ascending Node of the Moon's Orbit 5 sig. 24 deg. 14 min. 35 sec. And *December* the last Day, 1700, *Old Style*, at Noon, the Sun's mean Motion was 9 sig. 20 deg. 43 min. 50 sec. That of the Sun's Apogæum 3 sig. 7 deg. 44 min. 20 sec. The mean Motion of the Moon 10 sig. 15 deg. 19 min. 50 sec. Of the Moon's Apogæum 11 sig. 8 deg. 18 min. 20 sec. And of the ascending Node 4 sig. 27 deg. 24 min. 20 sec. For in twenty *Julian* Years, or in 7305 Days, the Sun goes thro' 20 rev. 9 min. 4 sec. The Motion of the Sun's Apogæum 21 min. The Moon's Motion 247 rev. 4 sig. 13 deg. 34 min. 5 sec. The Motion of the Moon's Apogæum 2 rev. 3 sig. 3 deg. 50 min. 15 sec. Of the Node, 1 rev. 26 deg. 50 min. 15 sec. All the aforesaid Motions are from the Point of the vernal Equinox. And if from them be subtracted the Procession, or Retrograde Motion of the Equinoctial Point itself, which was moved in the mean Time *in Antecedentia, viz.* 16 min. 40 sec. the Motions will remain in respect of the fixed Stars in 20 *Julian* Years; the Motion of the Sun, 19 rev. 11 sig. 29 deg. 52 min. 24 sec. That of the Sun's Apogæum 4 min. 20 sec. of the Moon, 247 rev. 4 sig. 13 deg. 17 min. 25 sec. Of the Moon's Apogæum, 2 rev. 3 sig. 3 deg. 33 min. 35 sec. Of the Moon's Node, 1 rev. 27 deg. 6 min. 55 sec.

MEAN DISTANCE *of a Planet from the Sun*, is the Right Line S P,



drawn from the Sun S to P, the Extremity of the conjugate Axis of the Ellipsis the Planet moves in, and this is equal to the Semi-Transverse Axis D C, and is so called, because it is a Mean between the Planet's greatest and least Distance from the Sun.

MEAN DIAMETER, *in Gauging*, is a Geometrical Mean between the Diameters at Head and Bung in any close Cask.

MEAN *and* EXTREAM PROPORTION. See *Extream* and *Mean Proportion*.

MEAN *or* MIDDLE PROPORTION *between any two Lines or Numbers*, is that which hath the same Proportion to a third Term, that the first bears to it.

1. Thus 6 is a mean Proportional between 4 and 9, because 4 : 6 :: 6 : 9.

2. The Square of a mean Proportional is equal to the Rectangle under the Extremes.

3. Two mean Proportionals between two Extreams cannot be found by a straight Line and a Circle; but it may be done by the Conic Sections very easily, or by the Conchoid, or Cissoid.

MEASURE, in Music, is a Quantity of the Length and Shortness of Time, either with respect to natural Sounds pronounced by the Voice, or artificial, drawn out of Musical Instruments; which Measure is adjusted in Variety of Notes, by a constant Motion of the Hand or Foot, down or up, successively and equally divided; so that every Down or Up, is called a *Time* or *Measure*, whereby the Length of a Semi-Breve is measured, which is therefore termed the *Measure-Note*, or *Time-Note*.

MEASURE *of an Angle*, is an Arch of a Circle described about the Angular Point.

MEASURE *of a Number*, is the

Number that measures it; as 2 is the Measure of 4.

Measure *of a Ratio*, is a Logarithm.

Measure *of a Solid*, is a Cube, whose Side is one Inch, Foot, Yard, or other determinate Length.

Measure *of a Superficies*, or *plain Figure*, is a Square, whose Side is one Inch, Foot, Yard, &c.

Here follow several very useful TABLES *of different Measures.*

A TABLE of the Foreign Measures, carefully compared with the English.

		Suppose an English *Foot divided into* 1000 *equal Parts, those here mentioned are in Proportion to it, as follows.*	*The* English *Foot divided into Inches, and Decimal Parts of an Inch.*
London	Foot	1.000	0 12 0
Paris *the Royal*	Foot	1.068	1 00 8
Amsterdam	Foot	.942	0 11 3
Brill	Foot	1.103	1 01 2
Antwerp	Foot	.946	0 11 3
Dort	Foot	1.184	0 02 2
Rynland, *or* Leyden	Foot	1.033	1 00 4
Lorrain	Foot	.958	0 11 4
Mechlin	Foot	.919	0 11 0
Middleburgh	Foot	.991	0 11 9
Strasburgh	Foot	.920	0 11 0
Bremen	Foot	.964	0 11 6
Cologn	Foot	.954	0 11 4
Frankfort ad Mœnam	Foot	.948	0 11 4
Spanish	Foot	1.001	1 00 0
Toledo	Foot	.899	0 10 7
Roman	Foot	.967	0 11 6
On the Monument of { Cestucicus Statilius. }		.972	0 11 7
Bononia	Foot	1.204	1 02 4
Mantua	Foot	1.569	1 06 8
Venice	Foot	1.162	1 01 9
Dantzick	Foot	.944	0 11 3
Copenhagen	Foot	.965	0 11 6
Prague	Foot	1.026	1 00 3
Riga	Foot	1.831	1 09 9
Turin	Foot	1.062	1 00 7
The Greek	Foot	1 007	1 00 1
Paris *Foot, according to Dr.* Bernard		1.066	

Uni-

Universal	*Foot*	1.089			
Old Roman	*Foot*	.970			
Bononian *Foot of* M. Auzout		1.140			
Lyons	*Ell*	3.976	3	11	7
Bologn	*Ell*	2.076	2	00	8
Amsterdam	*Ell*	2.269	2	03	2
Antwerp	*Ell*	2.273	2	00	2
Rynland, *or* Leyden	*Ell*	2.260	2	03	1
Frankfort	*Ell*	1.826	1	09	9
Hamburgh	*Ell*	1.905	1	10	8
Leipsick	*Ell*	2.260	2	03	1
Lubeck	*Ell*	1.908	1	09	8
Noremburgh	*Ell*	2.227	2	03	3
Bavaria	*Ell*	.954	0	11	4
Vienna	*Ell*	1.053	1	00	6
Bononia	*Ell*	2.147	2	01	7
Dantzick	*Ell*	1.903	1	10	8
Florence	*Brace*, or *Ell*	1.913	1	11	0
Spanish, *or* Castile	*Palm*	.751	0	09	0
Spanish *Vare*, or *Rod*, *which is four Palms*		3.001	1	00	0
Lisbon	*Vare*	2.750	2	09	0
Gibraltar	*Vare*	2.760	2	09	1
Toledo	*Vare*	2.685	2	08	2
Naples	*Palm*	.861	0	09	6
Naples	*Brace*	2.100	2	01	2
Naples	*Canna*	6.880	6	10	5
Genoa	*Palm*	.830	0	09	6
Milan	*Calamus*	6.544	6	06	5
Parma	*Cubit*	1.866	1	10	4
China	*Cubit*	1.016	1	00	2
Cairo	*Cubit*	1.824	1	09	9
Old Babylonian	*Cubit*		1	06	$\frac{24}{100}$
Old Greek	*Cubit*		1	06	$\frac{13}{100}$
Old Roman	*Cubit*		1	05	$\frac{420}{1000}$
Turkish	*Pike*	2.200	2	02	4
Persian	*Arash*	3.197	3	02	3

A Table

A TABLE *of* English *Long Measure.*

Inches.	*Palm.*	*Span.*	*Foot.*	*Cubit.*	*Yard.*	*Ell.*	*Pace.*	*Fath.*	*Pole.*	*Furl.*	*M.*
3											
9	3										
12	4	$1\frac{1}{3}$									
18	6	2	$1\frac{1}{2}$								
36	12	4	3	2							
45	15	5	$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{1}{4}$						
60	20	$6\frac{2}{3}$	5	$3\frac{1}{3}$	$1\frac{2}{3}$	$1\frac{1}{4}$					
72	24	8	6	4	2	$1\frac{1}{4}$	$1\frac{1}{5}$				
198	66	22	$16\frac{1}{2}$	11	$5\frac{1}{2}$	$1\frac{2}{5}$	$4\frac{1}{10}$	$2\frac{3}{4}$			
7920	2640	880	660	440	220	176	132	100	40		
63360	21120	7040	5280	3520	1760	1408	1056	880	320	8	

A TABLE *of Square Measure.*

Inches square.	*Feet sq.*	*Yards sq.*	*Paces sq.*	*Poles sq.*	*Rood sq.*	*Acres sq.*	*Miles.*
144							
1296	9						
3600	25	2 77					
39204	272.25	30.25	10.89				
1568160	10890	1210	435.6	40			
	43560	4840	1742.4	160	4		
		3097600	1115136	102400	2560	640	

A TABLE *of Dry Measure.*

Pints.	*Gallons.*	*Pecks.*	*Bushels.*	*Strikes.*	*Carnock, or Coom.*	*Seem, or Quarter.*	*Way.*	*Last.*
8								
16	2							
64	8	4						
128	16	8	2					
256	32	16	4	2				
512	64	32	8	4	2			
3072	384	102	48	24	12	6		
5120	640	320	80	40	20	10	12	

1 lb.	8 lb	16	64	128	256	512	3072	5120	*Troy.*
14 *oz*	7 lb.	14	56	1 C.	2 C.	4 C.	24 C.	40 C.	*Aver.*

A TABLE *of Wine-Measure, Honey, Oil,* &c.

								Pints.
							Gall.	8
						Rundl.	18	144
					Barrels.	$1\frac{3}{4}$	$31\frac{1}{2}$	252
				Terces.	$1\frac{1}{3}$	$3\frac{1}{3}$	42	336
			Hogshead.	$1\frac{1}{2}$	2	$3\frac{1}{2}$	63	504
		Punch.	$1\frac{1}{3}$	2	$2\frac{2}{3}$	$4\frac{2}{5}$	84	672
	Butt, or Pipe.	$1\frac{1}{2}$	2	3	4	7	726	1008
Tun.	2	3	4	6	8	14	252	2016

A TABLE *for Beer-Measure.*

					Pints.
				Gall.	8
			Firk.	9	72
		Kilderk.	2	18	144
	Barrels.	2	4	36	288
Hogshead.	2	4	8	72	576

A TABLE *for Ale-Measure.*

					Pints.
				Gall.	8
			Firk.	9	64
		Kilderk.	2	18	128
	Barrels.	2	4	36	256
Hogshead.	2	4	8	72	512

Mechanics, is the Geometry of Motion, being that Science which shews the Effect of Powers or moving Forces, so far as they are applied to Engines, and demonstrates the Laws of Motion.

Mechanics was very imperfect amongst the Ancients. All that is to be found of theirs upon this Subject, are *Archimedes de Centro Gravitatis Figurarum Planarum*, and *Pappus in* lib. 8. *Collect. Mathemat.* of the five mechanical Powers: nor have some of the more modern Authors done much more; such as *Guido Ubaldus*'s *Liber Mechanicorum*. —*Rohault*'s *Tractatus de Mechanica*. —*Lamy*'s Mechanics in *French*.—*Oughtred*'s *Mechanical Institutions*. —*Casatus*'s *Mechanica*.

Further Improvements are to be found in *Gallileo*'s *Mechanical Dialogues*.— *Torricellius*'s *Libri de Motu Gravium naturaliter Descendentium & Projectorum*— *Balianus*'s *Tractatus de Motu naturali Gravium*.— *Huygens*'s *Horologium Oscillatorium*. —*Leibnitz*'s *Resistentia Solidorum, in Acta Eruditor. An.* 1684. p. 319. and *Varignon*'s Papers in the *Comment. Academ. Reg. Scienc. An.* 1702. p. 87. —*Borellus*'s *Tractatus de Vi Percussionis; de Motionibus Naturalibus a Gravitate pendentibus; de Motu Animalium*.— *Huygens*'s *Tractatus de Motu Corporum ex Percussione*.— *Wallis*'s *Tractatus de Mechanica*, reckon'd by some a very good Piece. —*Keil*'s *Introduction to true Philosophy*.— *De la Hire*'s *Mechanics*.— *Mariotte*'s *Traité du Choc des Corps* —*Dechales*'s *Treatise of Motion*.— *Pardies*'s *Discourse of Local Motion*. —*Parent*'s *French Elements of Mechanics and Physics*.—Sir *Isaac Newton*'s *Principia*.— *Ditton*'s *Laws of Motion*.— *Herman*'s *Phronomia*.— *s'Gravesande*'s *Physics*.—*Euler*'s *Tractatus de Motu*.— *Desaguliers*'s *Mechanics*.—*Muschenbroeck*'s *Physics*, &c.

As to the Descriptions of Machines, we have *Strada*, *Zeisingius*, *Besson*, *Augustine de Ramellis*, *Boetler*, *Leopold*, *Sturmy*, *Perrault*, *Limbergh*, &c.

Mechanic Powers, (as they are called) are six, *viz.* the *Ballance*, the *Leaver*, the *Wheel*, the *Pulley*, the *Wedge*, and the *Screw*; to some or other of which, the Force of all mechanical Inventions must necessarily be reduced. See those Words.

Mechanical Philosophy, is the same with the Corpuscular, which endeavours to explicate the Phænomena of Nature from mechanical Principles, *i. e.* from the Motion, Rest, Figure, Position, Magnitude, *&c.* of the minute Particles of Matter. And these Principles are frequently called

Mechanical Causes: And also the

Mechanical Affections of Matter.

Mechanical Curve, is one whose Nature cannot be express'd by an *Algebraic* Equation.

Mechanical Solution *of a Problem*, in Mathematics, is either when the thing is done by repeated Trials, or when the Lines made use of to solve it, are not truly geometrical. Thus the Method of *Nicomedes*, *Eratosthenes*, *Pappus*, and *Vieta*, for finding two mean Proportionals; and that of *Nicodemus* and *Dinostratus*, for dividing an Angle into any Parts assigned, by means of the Quadratrix, is mechanical; because the former is done by repeated Trials, and the latter by means of a Curve that is not truly geometrical.

Medium, in Natural Philosophy, signifies that peculiar Constitution of any Space or Region through which Bodies move. Thus the *Æther* is suppos'd by some to be the Medium in which the Planets and heavenly Bodies move; and by the

means

means of which it is, that all Animals, as Insects, Birds, Beasts, and Men, can breathe and live: But Water is the Medium in which Fishes live and move. Glass is also called a *Medium*.

MEMBRETTO, in Architecture, is the *Italian* Term for a Pilaster, that bears up an Arch. These are often fluted, but not with above seven or nine Channels. They are frequently used to adorn Door-Cases, Gallery-Fronts, and Chimney-Pieces, and to bear up the Cornishes and Freezes in Wainscot.

MENISCUS GLASSES, are those which are Convex on one side, and Concave on the other.

As the Difference of the Semi-Diameters of the Convexity and Concavity, to the Semi-Diameter of the Concavity, so is the Diameter of the Convexity to the Focal Length.

MENSURABILITY, is an Aptitude in a Body, whereby it may be applied or conformed to a certain Measure.

MENSURATION, *or* MEASURING, is to find the superficial Area, or solid Content of Surfaces and Bodies.

MERCATOR'S CHART, or PROJECTION, is a Projection of the Face of the Earth *in plano*, wherein the Meridians, Parallels, and Rhumb-Lines, are all straight Lines, and the Degrees of Longitude are all equally distant from one another; but the Degrees of Latitude increase towards the Poles in the same Proportion, that the Parallel-Circles on the Globe decrease, *viz.* in the Ratio of the Radius to the Sine Complement of the Latitude; or, the Distance of any Parallel of Latitude from the Equator, is always as the Sum of all the Secants answerable to every Point in that Arch of Latitude to the same Sum of so many times the Radius, or (more accurately) the Distance of any Parallel of Latitude from the Equator is to that Arch of Latitude (extended into a right Line) as the Curvelin'd Space contain'd under the Radius, so much of the Curve of the Figure of the Secants (see that Word) as is cut off by an Ordinate, raised at the Extremity of the right-lin'd Abscis or Arch of Latitude, that Abscis and that Ordinate, is to the Rectangle under the Radius, and the said Abscis.

1. Though the plain Chart be very easy and useful in short Voyages, if you sail home in or near the opposite Rhumb you went by, as the Ancients, who being Coasters, did before the Use of the Compass; yet forasmuch as few Places, or indeed none, but such as lie under the Equinoctial, can therein be expressed according to their true Situation and Distance one from another; but if they be laid down true by the Course and Distance, the Difference of Longitude will be false; if they be laid down by the Course and Difference of Longitude, then will the Distance and Difference of Latitude be more than it should be; and if they be laid down by the Distance and Difference of Longitude, (which in many Cases is impossible,) then the Difference of Latitude will always be too little, and the Rhumb too wide from the Meridian; and if they be laid down by their Latitude and Departure, then the Course will be wide, and the Distance too much, &c

2. It was the great Study of our Predecessors to contrive such a Chart *in plano*, with straight Lines, on which all or any Parts of the World might be truly set down, according to their Longitudes, Latitudes, Bearings, or Distances.

3. A way was hinted for this near two thousand Years since by *Ptolemy*, and a general Map according thereto,

to, made in the preceding Age by one *Mercator*, but the thing demonſtrated, and a ready way ſhewed of deſcribing it, was not till Mr. *Wright* taught to enlarge the Meridian-Line by the continual Addition of Secants; ſo that all Degrees of Longitude might be proportional to thoſe of Latitude, as on the Globe: Which he has done after ſuch an excellent manner, that in many reſpects it is far more convenient for the Navigator's Uſe, than the Globe itſelf, and will truly ſhew the Courſe and Diſtance from Place to Place, which way ſoever a Ship ſails forth, or returns.

4. The *Meridian Line*, in *Mercator*'s Chart, is a Scale of Logarithmic Tangents of the Half-Complements of the Latitude.

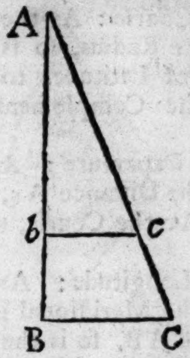
The Differences of Longitude on any Rhumb, are the Logarithms of the ſame Tangents, but of a different Species; being proportioned to one another, as are the Tangents of the Angles made with the Meridian.

Hence any Scale of Logarithmic Tangents is a Table of the Differences of Longitude, to ſeveral Latitudes, upon ſome determinate Rhumb or other; and therefore, as the Tangent of the Angle of ſuch a Rhumb, to the Tangent of any other Rhumb; ſo is the Difference of the Logarithms of any two Tangents, to the Difference of Longitude on the propoſed Rhumb, intercepted between the two Latitudes, of whoſe Half-Complements you took the Logarithmic Tangents.

Here follow the ſeveral Caſes, and their Proportions, in Mercator's *Sailing.*

1. One Latitude, Courſe, and Diſtance given: to find the other Latitude, Departure and Difference of Longitude.

In the Right-angled Triangle ABC, the Line A*c* repreſents the Diſtance: A*b* the Difference of Latitude, *bc* the Departure; as in



plain Sailing; AB the Meridional Difference of Latitude, according to the true Chart, commonly called *Mercator's Chart*, and BC the Difference of Longitude.

For the Departure as the Radius to the Diſtance A*c* :: ſo is the Sine of the Courſe *b*A*c*, to *bc* the Departure.

For the Difference of Latitude: As the Radius to the Diſtance A*c*, ſo is the Sine of A*cb*, the Complement of the Courſe, to the Difference of Latitude A*b*.

For the Difference of Longitude, As the Radius, to AB the Meridional Difference of Latitude, ſo is the Tangent of the Courſe BAC, to BC the Difference of Longitude.

2. Both Latitudes and Courſe given; to find the Diſtance, Departure, and Difference of Longitude.

For the Diſtance: As the Radius to A*b* the Difference of Latitude; ſo is the Secant of *b*A*c* the Courſe, to A*c* the Diſtance.

For the Departure: As the Radius is to the Diſtance A*c*; ſo is the Sine of *b*A*c* the Courſe, to *bc* the Departure.

For the Difference of Longitude: As the Radius is to AB, the Meridional Difference of Latitude; ſo is the Tangent of BAC the Courſe, to BC the Difference of Longitude.

3. Both Latitudes and Diſtance given: to find the Courſe, Departure, and Difference of Longitude.

For the Courſe: As the Diſtance A *c* is to the Radius, ſo is A *b* the Difference of Latitude, to the Sine of A *c b* the Complement of the Courſe.

For the Departure: As the Radius is to the Diſtance A *c*, ſo is the Sine of *b* A *c* the Courſe, to *b c* the Departure.

For the Longitude: As the Radius is to the Meridional Difference of Latitude A B, ſo is the Tangent of B A C the Courſe, to B C, the Difference of Longitude.

4. Both Latitudes and Difference of Longitude given: to find the Courſe, Diſtance, and Departure.

For the Courſe: As A B the Meridional Difference of Latitude, is to the Radius; ſo is BC, the Difference of Longitude, to the Tangent of B A C, the Courſe.

For the Diſtance: As the Radius is to A B the Difference of Latitude, ſo is the Secant of B A C the Courſe, to A *c* the Diſtance.

For the Departure: As the Radius is to A *c* the Diſtance; ſo is the Sine of *b* A *c* the Courſe, to *b c* the Departure. Or, as the Radius is to A *b* the Difference of Latitude; ſo is the Tangent of *b*A*c* the Courſe, to *b c* the Departure.

5. One Latitude, Courſe, and Difference of Longitude given, to find the other Latitude, Diſtance, and Departure.

For the Latitude: As the Tangent of B A C the Courſe, is to B C the Difference of Longitude; ſo is the Radius, to the Meridional Difference of Latitude A B.

For the Diſtance: As the Radius is to A*b*, the Difference of Latitude; ſo is the Secant of *b*A*c* the Courſe, to A *c* the Diſtance.

For the Departure: As the Radius is to A *b* the Diſtance, ſo is the Sine of *b* A *c* the Courſe, to the Departure *bc*.

6. Both Latitudes and Departure given: to find the Courſe, Diſtance, and Difference of Longitude.

For the Courſe: As the Difference of Latitude A *b*, is to the Radius, ſo is the Departure *b c*, to the Tangent of *b* A *c* the Courſe.

For the Diſtance: As the Sine of A *c b* the Complement of the Courſe, to the Difference of Latitude A*b*; ſo is the Radius to the Diſtance A *c*.

For the Longitude: As the Radius is to the Meridional Difference of Latitude A B; ſo is the Tangent of B A C the Courſe, to the Difference of Longitude B C.

Mercator's Sailing, is the Art of finding on a Plane the Motion of a Ship upon any aſſigned Courſe, true in Longitude, Latitude, and Diſtance; the Meridians being all parallel, and the Parallels of Latitude ſtraight Lines.

Mercury, is the Name of one of the Planets, revolving about the Sun.

Mercury, is the leaſt diſtant from the Sun of any of the Planets; its mean Diſtance from the Sun is 387 of ſuch Parts of which the Earth's is 1000, its Excentricity 80, the Inclination of its Orbit is 6 deg. 52 min. It performs its Revolution round the Sun in 87 Days, 23 Hours. Its greateſt Elongation is about 28 Degrees. There has not yet been obſerv'd any Spots in it; neither do we know whether it revolves about its Axis; but it is probable it does. Its Magnitude to that of the Earth is as 216 to 343.

In the Years 1736, 1743, 1756, 1769, 1776, 1782, 1789, in *October*, this Planet will be ſeen in the Sun near the aſcending Node; and in the Years 1753, 1786, 1799, it will appear in the Sun, in the Month of *April*, near the other Node.

Meri-

Meridian, is a great Circle passing through the Poles of the World, and both *Zenith* and *Nadir*, crossing the Equinoctial at Right Angles, and divides the Sphere into two equal Parts, one East, the other West, and hath its Poles in the East and West Points of the Horizon. 'Tis called *Meridian*, because when the Sun comes to the South Part of this Circle, 'tis then *Meridies, Mid-Day*, or *High-Noon*; and then the Sun hath his greatest Altitude for that Day, which therefore is called the *Meridian Altitude*.

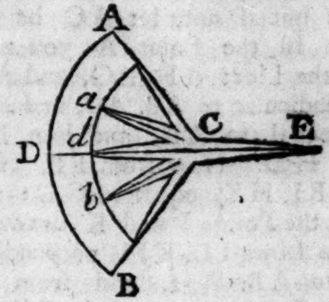
These Meridians are various, and change according to the Longitude of Places; so that they may be said to be infinite in Number: for that all Places from East to West have their several Meridians; but there is (or should be) one fixed, which is called the *First Meridian*.

Meridian *on the Globe or Sphere*, is represented by the Brazen Circle, in which the Globe hangs and turns. 'Tis divided into four 90's, or 360 Degrees, beginning at the Equinoctial on it. Each way from the Equinoctial, on the Celestial Globes, is counted the South and North Declination of the Sun or Stars; and on the Terrestrial Globe, the Latitude of Places, North or South.

Upon the Terrestrial Globes there are usually drawn 36 Meridians, thro' every 10th Degree of Longitude.

Meridian Line, is the common Section of the Meridians, and the Plane of the Horizon, and so runs on North and South.

1. To draw a Meridian Line, there are several ways, and many Instruments have been contriv'd for that purpose; but the following Method is a very easy and good one. In an horizontal Plane, which is easy to determine, describe several Concentric Circles BA, *b a*, &c. And in the Centre C E erect a Pin of about a Foot long, perpendicu-



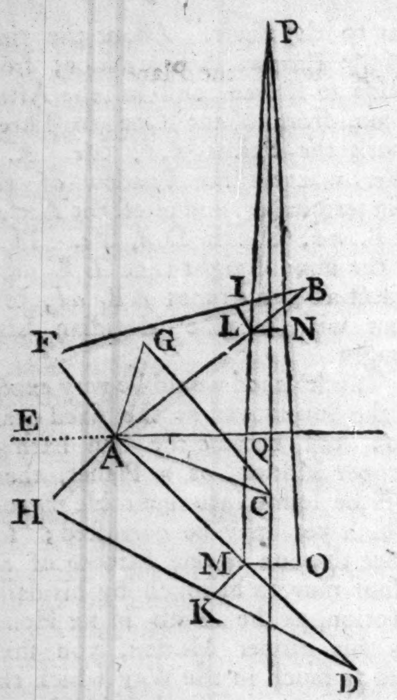
lar to the Plane. About the time of the Tropics before Noon, from Nine to Eleven, and in the Afternoon, from about One to Three, mark the Points B, *b*, *&c.* A, *a*, *&c.* wherein the Shadow of the Pin terminates, and bisect the Arches A B, *a b*, *&c.* in D, *d*, *&c.* Then if the same straight Line D E does bisect all the Arches A B, *a b*, *&c*, that will be the Meridian Line sought.

This Method would be very exact, if the Sun moved as the fixed Stars do; but because the Sun hath a proper Motion, as a Planet, there will be some inconsiderable Error, which yet may be corrected; for since the Sun in one Minute of an Hour moveth as much by his daily Motion, as he loseth in six Hours by his proper Motion, you shall add as much in the Way which the Shadow goes in the last Marks, as that Shadow moveth in one Minute, which you may measure by a Pendulum; so the last Points will not be taken just in the Circles, but a little without them.

If A B, A C, and A D, be three Shadows, made in one Day, upon an Horizontal Plane, by the Pin A E, perpendicular to that Plane, the Meridian Line may be drawn thus:

 If

If two of these Shadows are equal, then the Line drawn from the Point A, perpendicular to a Line joining their Extremes, will be the Meridian; but if not, let AC be the least. In the Point A you must raise the Lines AF, AG, and AH, perpendicular to AB, AC, and AD, and equal to AE, and join FB, GC, HD. Now from FB, HD, take FI, HK, equal to GC; and from the Points I and K draw the Right Lines IL, KM, perpendicular to AB, AD, and from the Points L, M, you must let fall two



more Perpendiculars LN, MO, to the Line joining L and M, which let be equal to LI and MK. Now, let P be the Intersection of the Lines joining the Points M, L, and O, N. Then if a Right Line be drawn thro' P and C, a Perpendicular AQ from A to the Line CP, will be the Meridian. See the Demonstration of this in *Van Schouten*'s *Exercitationes Geometricæ*.

Meridian Line, on Gunter's Scale, is divided unequally towards 87 Degrees, (whereof 70 Degrees are about one half) in such manner as the Meridian in *Mercator*'s *Chart* is divided and number'd.

Its Uses are many. For, 1. It serves to graduate a Sea-Chart according to the true Projection. 2. Being joined with a Line of Chords, it serves for the Protraction and Resolution of such right-lined Triangles as are concerned in Latitude, Longitude, Rhumb, and Distance, in the Practice of Sailing; as also in pricking the Chart truly at Sea.

Meridian (Magnetical) is a great Circle passing through or by the Magnetical Poles; to which Meridians, the Compass (if not otherwise hinder'd) hath respect.

Meridional Distance, in Navigation, is the same with the *Departure*, Easting or Westing, or under which the Ship now is, and any other Meridian she was before under.

Meridional Parts, Miles, or Minutes, in Navigation, are the Parts by which the Meridians in *Mercator*'s Chart do increase, as the Parallels of Latitude decrease.

And the Co-sine of the Latitude of any Place being equal to the Radius or Semi-Diameter of that Parallel, therefore in *Mercator*'s Chart, this Radius being the Radius of the Equinoctial, or whole Sine of 90°, the Meridional Parts at each of the Arches contained between that Latitude and the Equinoctial do decrease.

The Tables therefore of Meridional Parts, which you have in Books of Navigation, are made by the continual Addition of Secants, and calculated in some Books (as in Sir *Jonas Moore*'s Tables) for every Degree and Minute of Latitude; and these will serve either to make or graduate a *Mercator*'s Chart, or to work *Mercator*'s Sailing.

Merlon,

Merlon, in Fortification, is that Part of the Parapet which lies betwixt two Embrasures, being from eight to nine Foot long on the side of the Cannon, and six on the side of the Field; as also six Foot high, and eighteen thick.

Mesolabium, is the Name of an Instrument for finding mean Proportionals.

Metal. The Outside or Surface of a Piece of Ordnance is called the *Superficies of her Metal:* When the Mouth of a great Gun lies lower than her Breech, they say, she lies under Metal; but if she lies truly level, point-blank, or right with the Mark, they say, she lies right with her Metal.

Metops, is the square Space between the Triglyphs of the *Doric* Freeze, which among the Ancients used to be adorned with the Heads of Beasts, Basons, Vases, and other Instruments used in sacrificing. A Demi-Metops is a Space somewhat less than half a Metops, at the Corner of the *Doric* Freeze.

Microcoustics, the same with *Microphones*.

Micrometer, is an Instrument fitted to a large Telescope in the Focus of the Object-Glass, for measuring the apparent Diameters of the Celestial Bodies, and small Distances that do not exceed a Degree, or a Degree and an half.

There are several sorts of these Instruments, whereof some are Movements consisting of a Plate or Face divided like a Clock or Watch, with an Index or Hand, which being turn'd, moves two sliding Plates of Brass that carry two parallel Hairs, and counts on the Plate the Revolutions of the Screws that move the Plates, whose Threads are extremely fine.

The apparent Diameters for the Distances of any Objects that are less than a Degree, or a Degree and a half, that are contained between the two parallel Hairs of the Micrometer in the Focus of the Object-Glass of a Telescope, are proportional to the Revolutions of the Index required to separate the Hairs, so as to catch those Diameters or Distances.

Concerning this Instrument, see what Mr. *Auzout* says in a little Treatise of it contain'd *in divers Ouvrages de Mathematique & de Phisique, par Messieurs de l'Academie Royale des Sciences*, Mr. *de la Hire*'s *Astronomicæ Tabulæ*; Mr. *Townley*, in the *Philos. Transact.* N° 21. *Wolfius*, in his *Elem. Astron.* §. 508. Dr. *Hook*, in the *Philosoph. Transact.* N° 29. Mr. *Hevelius*, in the *Acta Eruditorum, Ann.* 1708. Mr. *Balshaser*, in his *Micrometria*. But the *Micrometers* of the *ingenious* Mr. *George Graham*, are far better than those of any body else, both as to Structure and Workmanship.

Microphones, are Instruments contrived to magnify small Sounds, as Microscopes do small Objects.

Microscope, is a dioptric Instrument, by which minute Objects are very much augmented, and seen distinctly. Some of these are called *single ones*, being such that have but one small *Lens*; others are compound ones, consisting of several *Lens's*.

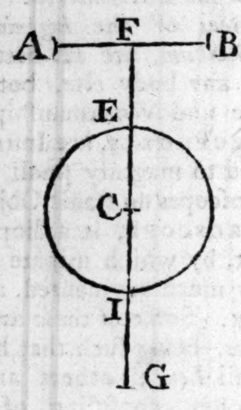
1. We are uncertain where and by whom Microscopes were invented; but this we know, that they were unknown till the Year 1618, because *Hieronymus Surturus*, who writ a Book that Year of the Invention and Fabrick of the Telescope, makes no mention of them.

2. Mr. *Huygens*, in his *Dioptrics*, will have one *Drebbel*, a *Dutchman*, to be the Inventor of the Double or Compound Microscope in the Year 1621; and *Franciscus Fontana*, a *Neapolitan*, in a Book of *Observations*, published by him in the Year

1646, ſays, that he himſelf happened upon the Invention of the Compound Microſcope in the Year 1621.

3. If an Object be placed in the Focus of the Convex-Lens of a ſingle Microſcope, and the Eye be very near on the other ſide, the Object will appear diſtinct in an erect Situation, and augmented in the Ratio of the Focal Diſtance of the *Lens*, to ſuch a Diſtance, at which, if the Object was placed, the naked Eye would perceive it diſtinctly, which is about eight Inches for good Eyes.

4. If the Object A B be placed in the Focus F, of a ſmall Glaſs Sphere, and the Eye be put in the Focus G, the Object will appear di-



ſtinct, and in an erect Poſture augmented, as to Diameter in the Ratio of $\frac{3}{4}$ of the Diameter E I to the Diſtance of about eight Inches. If the Diameter of the ſmall Sphere be $\frac{1}{10}$ of an Inch; then $CE = \frac{1}{20}$, and $FE = \frac{1}{40}$, and ſo $FC = \frac{3}{40}$. Whence the true Diameter of the Object to the Apparent, is as 1 to 103 nearly.

5. Microſcopes made of ſmall Glaſs Spheres will magnify Objects more than thoſe made of Lens's; becauſe ſmall Glaſs Spheres may be made far more little than thoſe of Lens's. If the Diameter of a Sphere be $\frac{1}{16}$ of an Inch, it will magnify the Diameter of an Object in the Ratio of 1 to 170 nearly; the Superficies in the Ratio of 1 to 28900, and the Solidity in the Ratio of 1 to 4913000.

6. The more an Object is amplified by a Microſcope, the leſs Part thereof is comprehended at one view.

7. The Appearance of any given Object, formed by any given Glaſs or Combination of Glaſſes, becomes obſcure in ſuch proportion as its Magnitude increaſes.

8. Equal Appearances of the ſame Object, formed by different Combinations, become obſcure in ſuch proportion, as the Number of Rays conſtituting each Pencil decreaſes, that is, in proportion to the Smallneſs of the Object-Glaſs.

9. Wherefore, if the Diameter of the Object-Glaſs exceeds the Diameter of the Pupil, as many times as the Diameter of the Appearance exceeds the Diameter of the Object; the Appearance ſhall appear as clear and bright as the Object itſelf.

10. The Diameter of the Object-Glaſs cannot be ſo much increaſed, without increaſing at the ſame time the focal Diſtances of all the Glaſſes, and conſequently the Length of the Inſtrument: Otherwiſe the Rays would fall too obliquely upon the Eye-Glaſs, and the Appearance become confuſed and irregular.

11. Sir *Iſaac Newton*, in his *Optics*, Book II. Part III. ſays, That if Microſcopes are or can be ſo far improved as with ſufficient Diſtinctneſs to repreſent Objects five or ſix hundred times bigger than at a Foot Diſtance they appear to the naked Eye; he hoped that we might be able to diſcover ſome of the greateſt of the Corpuſcles of Bodies; and by one which would magnify three or four thouſand times, perhaps, all

hoſe that produce Blackneſs might be diſcovered. And if this could be attained to, (*viz.* by Glaſſes to diſcover the Conſtituent Particles of Bodies) he fears it would be the utmoſt Improvement of this Senſe of ſeeing; for it ſeems impoſſible to ſee the moſt ſecret and noble Works of Nature within the Corpuſcles, becauſe of the Tranſparency of the Corpuſcles.

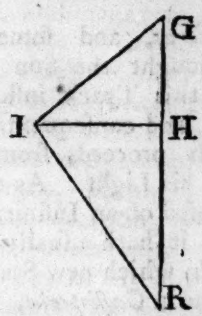
12. The ſame Gentleman in the *Philoſoph.Tranſ.* N° 88. from the Difference he had found between compound and ſimple Colours, takes occaſion to communicate a way for the Improvement of Microſcopes by Refraction, *viz.* by illuminating the Object in a darken'd Room with Light of any convenient Colour not too much compounded; by which means the Microſcopes will with Diſtinctneſs bear a deeper Charge, and a larger Aperture.

Some of the Writings about Microſcopical Obſervations, are *Franciſcus Fontana*'s *Obſervationes cæleſtium terreſtriumque Rerum. Hook*'s *Micrography. Malpighius*'s *Anatomia Plantarum*; his *Tractatus de Ovo incubato, de Bombyce, de Viſcerum ſtructura. Leewenhoeck*'s *Arcana Naturæ detectæ. Bonanni*'s *Micrographia curioſa.*

MIDDLE LATITUDE, in Navigation, is half the Sum of two Latitudes. And

MIDDLE LATITUDE SAILING, is the manner of ſolving the ſeveral Caſes of *Mercator's* Sailing, without the Meridional Parts, by taking the middle Latitude; and this nearly agrees with *Mercator*'s Sailing.

If the Line G R be drawn, and the Angle G R I be made at R, equal to the Complement of the middle Latitude: And the Difference of Longitude be ſet from R to I, and the Perpendicular I H be let fall, and the Difference of Latitude be ſet off from H to G, and the Line I G be drawn; then the Angle I G H is the Courſe, G I the Di-



ſtance, and I H the Departure in middle Latitude Sailing. And

As the Radius is to R I the Difference of Longitude, ſo is the Sine of H R I the Complement of the middle Latitude, to H I the Departure; and as G H the Difference of Latitude is to the Radius, ſo is H I the Departure to the Tangent of H G I the Courſe.

And as the Sine of H G I the Courſe, to I H the Departure, ſo is the Radius to I G the Diſtance.

MILKY-WAY, VIA LACTEA, or GALAXY, is a broad white Path or Track, encompaſſing the whole Heavens, and extending itſelf in ſome Places with a double Path; but for the moſt part with a ſingle one. Some of the Ancients, as *Ariſtotle*, &c. imagined that this Path conſiſted only of a certain Exhalation hanging in the Air; but by the Teleſcopical Obſervations it hath been diſcovered to conſiſt of an innumerable Number of fixed Stars, different in Situation and Magnitude, from the confuſed Mixture of whoſe Light, its white Colour is ſuppoſed to be occaſioned. It paſſes through the Conſtellations of *Caſſiopeia*, *Cygnus*, *Aquila*, *Perſeus*, *Andromeda*, Part of *Ophiucus* and *Gemini*, in the Northern Hemiſpheres; and in the Southern, it

takes in Part of *Scorpio, Sagittarius, Centaurus*, the *Argonavis*, and the *Ara*.

Metrodorus, and ſome *Pythagoreans*, thought the Sun had once gone in this Track inſtead of the Ecliptic; and conſequently, that its Whiteneſs proceeds from the Remains of his Light. As the *Galaxy* is compoſed of an Infinity of ſmall Stars, ſo it hath uſually been the Region in which new Stars appear, as the Star in *Caſſiopæia*, which was ſeen *A. D.* 1572, that in the Breaſt of the Swan, and another in the Knee of *Serpentarius*, and ſeveral others, which have appeared for a while, and then become inviſible again.

MILITARY ARCHITECTURE, the ſame with *Fortification*.

MINE, in Fortification, is a Hole dug or made by a Pioneer under the Rampart, or under the Face of the Baſtion, whereto there are ſeveral oblique and winding Paſſages: When it is finiſhed, divers Barrels of Powder are placed therein, together with a Train or Saucidge; and the Quantity of Powder is proportioned to the Height and Weight of the Body which is to be blown up.

There are alſo Mines ſprung in the Field, which are called *Fougades*. The Alley or Paſſage of a Mine is uſually about four Foot ſquare; at the End of which is the *Chamber of the Mine*, as they call it. The farther it is carried on, the more it is ſubject to be diſcovered by the Enemy. Therefore, 'tis beſt not to aim at mining too far, and to make a new one where the former takes no Effect. Concerning theſe, ſee *Lambion*, in his *Praxis Architectonica*; *Surire de St. Remy*, in his *Memoires d'Artillerie*, Tom. I. p. 154, and foll. *Wolfius*, in his *Element. Pyrotech.* §. 147. & *ſeq.*

MINE-DIAL, is a Box and Needle, with a braſs Ring divided into 360 Degrees, with ſeveral Dials graduated thereon, generally made for the Uſe of Miners.

MINIM, a Term in Muſic; being the fourth Note of Time, and is mark'd thus q.

MINION, a ſort of a Cannon, is either large or ordinary. The large Minion is one of the longeſt Size, and has its Bore three Inches and a quarter Diameter, and is a thouſand Pound Weight. Its Load is three Quarters of a Pound of Powder: Its Shot three Inches Diameter, and three Pound three Quarters Weight: Its Length eight Foot, and its Level-Range an hundred and twenty-five Paces.

The ordinary Minion: Its Bore is three Inches in Diameter, and weighs about eight hundred, or ſeven hundred and fifty Pounds Weight: It is ſeven Foot long: Its Load two Pounds and a half of Powder: Its Shot near three Inches Diameter, and weighs three Pounds and four Ounces; and it ſhoots point-blank an hundred and twenty Paces.

MINUTE, is the 60th Part of a Degree or Hour.

MINUTE, in Architecture, is ſometimes taken for a Part of a Module.

MITRE, in Architecture, is the Workmen's Term for an Angle, that is juſt forty-five Degrees, or half a Right one; and if it be a Quarter of a Right Angle, they call it a *Half Mitre*. And they have an Inſtrument made to this Angle, which they call the *Mitre Square*; with which they ſtrike Mitre-Lines on their Quarters or Battens; and for Diſpatch they have a *Mitre-Box*, as they call it, which is made of two Pieces of Wood, each about an Inch thick, and one is nailed upright upon the Edge of the other; the upper Piece hath the Mitre-Lines ſtruck upon it on both Sides, to direct the Saw in cutting the Mitre-

Joints readily, by only applying the Piece into this Box.

Mix'd-Lined Figure, is one consisting of straight and crooked Lines.

Mixed Number, is one that is part integer, or a whole Number, and part a Fraction; as $4\frac{3}{6}$, $10\frac{1}{5}$, &c.

Mixed Ratio, or Proportion, is when the Sum of the Antecedent and Consequent is compared with the Difference between Antecedent and Consequent, as if

$$\begin{matrix} 4 : 3 :: 16 : 12 \\ a : b :: c : d \end{matrix} \quad \text{Then}$$

$$\begin{matrix} 7 : 1 :: 28 : 4 \\ a+b : a-b :: c+d : c-d \end{matrix}$$

Moat, in Fortification, is a hollow Space or Ditch dug round a Town or Fortress which is to be defended; wherefore, the Length and Breadth often depends upon the Nature of the Soil, according as it is marshy or rocky: But Moats in general may be from sixteen to twenty-two Fathom broad, and from fifteen to twenty-five Foot deep.

Dry Moat, is that which is destitute of Water, and ought to be deeper than one that is full of Water.

Lined Moat, is that whose Scarp and Counterscarp are cased with a Wall of Masons-Work lying in Talus, or a Slope.

Flat-bottom'd Moat, is that which hath no sloping, its Corners being somewhat rounded. All Moats must be well flanked, and in general so wide, as that no Ladder, Tree, &c. can reach a-cross them. If the Ditch be dry, or has but little Water, there is usually another small Trench cut quite along the Middle of it.

Model, in Architecture. See *Module*.

Modes, in Music. See *Mood*.

Modillions, in Architecture, are little inverted Consoles under the Soffit or Bottom of the Drip, in the *Ionic*, *Composite*, and *Corinthian* Cornices, and ought to correspond to the Middle of Columns. These are particularly affected in the *Corinthian* Order, where they are always enrich'd with carved Works. In the *Ionic* and *Composite* they are more simple, having seldom any Ornaments, excepting sometimes a single Leaf underneath.

Module, in Architecture, is a little Measure, by which we mean any Bigness or Extent taken at pleasure, to measure the Parts of a Building by, and is usually determined by the lower Diameter of the Column and Pilasters. *Vignola*'s Module, which is equal to the Semi-Diameter of the Column, is divided into twelve Parts in the *Tuscan* and *Doric*, and into eighteen in the rest of the Orders. The Module of *Palladio*, *Scammozzi*, M. *De Cambray*, and M. *Desgodetz*, which is likewise equal to the Semi-Diameter, is divided into thirty Parts.

Moineau, is a Name the *French*, and some Modern Writers of Fortification, give to a little Plat-Bastion, which is raised before a Curtain that is too long, and which hath two other Bastions at the Ends of it; for they being out of Musket-Shot, one or the other must be defended by some such thing as this Moineau or Plat-Bastion.

Sometimes the *Moineau* joins to the Curtain, and sometimes is disjoined from it by a Moat.

Moments, are sometimes taken for the least and most insensible Parts of Time; as when we say, such a thing was done in a Moment.

1. In Mathematics, Moments are such indeterminate and instable Parts of Quantity, as are supposed to be in a perpetual Flux, *i. e.* either continually decreasing or increasing; which latter are taken for affirmative and positive Moments, and the former

former for negative or subtractible ones. And these continually increasing or decreasing Particles are supposed to be infinitely small; for as soon as ever they come to be of any finite Magnitude, they cease to be Moments. Moments therefore are to be looked upon not as the generative Principles of finite Magnitude; but to be inceptive only of them.

2. And because 'tis the same thing, if in the room of these Moments, the Velocities of their Increases or Decreases be made use of, or the finite Quantities proportionable to such Velocities; this Method of Proceeding, which considers the Motions, Changings, or Fluxions of Quantities, hath come to be called *Fluxions*.

3. Moments, or *Momenta*, also in a Physical Sense, as they are used in reference to the Laws of Motion, signify the Quantities of Motion in any moving Bodies; and sometimes, simply the Motion itself: and they define it to be the *Vis insita*, or Power by which any moving Bodies do continually change their Places.

4. And in comparing the Motions of Bodies, the Ratio of these Moments is always compounded of the Quantity of Matter in, and the Celerity of the moving Body; so that the Moment of any moving Body may be consider'd as a Rectangle under the Quantity of Matter into the Celerity. And since 'tis certain, that all equal Rectangles have their Sides reciprocally proportionable, (14 *E.* 6 *Eucl.*) therefore if the Moments of any moveable Bodies are equal, the Quantity of Matter in one, to that of the other, will be reciprocally, as the Celerity of the latter to the Celerity of the former, and *vice versa*.

5. The Moment of any moving Body may be considered also as the Aggregate or Sum of all the Moments of the Parts of that Body; and therefore, where the Magnitudes and Number of any Particles are the same; and where they are moved with the same Celerity, there will be the same Moments of the Wholes.

6. M. *Leibnitz*, *Huygens*, *Bernoulli*, *Wolfe*, and some other Foreigners, have all been drawn into an horrid Error concerning the *Momenta*, or Force of falling Bodies: For they say, that the Forces of falling Bodies, at the Ends of the Fall, are not as the Velocities into the Quantities of Matter; but as the Squares of the Velocities into the Quantities of Matter. And all the Proof of this, by Experience, is a fallacious one, of suspending Balls by Threads to the Ceiling over Vessels of congealed Tallow, Clay, Wax, or any other yielding Substance; and then letting the Balls fall, and make Pits in the yielding Substance: for when the Balls were equal, and one weigh'd one Pound, and the other two, and the lighter Ball hung twice the Height of the other from the Surface of the Tallow; yet they made Pits in the Tallow of the same Depth: And from this Experiment they would have their *Momenta* to be equal, and consequently their proper Weights are in the reciprocal Ratio of the Spaces which the said Bodies describe by their Fall; and because these Spaces are in the same Ratio as the Squares of the Velocities; therefore, the Force of a falling Body is as the Body itself into the Square of the Velocity at the End of the Fall.

7. M. *s'Gravesande*, in his *Institutiones Philosophiæ Newtonianæ*, contradicts himself about this matter; for he says, *pag.* 75. *Dum pressione corpus acceleratur, manente equali pressione in corpus agenti, non augetur celeritas æquabiliter.* And therefore, according to this, if I take him right,

right, the Motion of a Body that falls freely ſhort Spaces, is not accelerated equally in equal Times: And ſo the Celerity which is acquired in the Fall, is not as the Time in which the Body has fallen; and conſequently the Spaces gone thro' from the beginning of the Fall, will not be to one another, as the Squares of the Times or Velocities in which the Body fell; and yet in the Experiments, that he and *Polenus* has made to prove, that the Forces of falling Bodies are as the Matter into the Square of the Velocity, this new Propoſition follows from the Spaces gone thro' by the Fall of Bodies, being as the Squares of the Times.

8. See concerning this in the *Acta Eruditorum*, *An.* 1686. *p.* 161. *Hiſtoire des Ouvrages des Scavans*, *An.* 1690. *p.* 451. *Journal Literaire*, Tom. XII. p. 1, 190. *Polenus*, in *Libro de Caſtellis*, &c. But Dr. *Deſaguliers* has ſhewn them all to be falſe in this Point, in the *Philoſophical Tranſactions*, N° 375, 376.

Monades. See *Digits*.

Monochord, a kind of Inſtrument anciently of ſingular Uſe for the regulating of Sounds: But ſome appropriate the Name of Monochord to an Inſtrument that hath only one ſingle String, as the Trumpet-Marine.

The Ancients made uſe of the Monochord to determine the Proportion of Sounds to one another; when the Chord was divided into two equal Parts, ſo that when the Terms were as 1 and 1, they call'd them *Uniſons*; but if they were as 2 to 1, they call'd them *Octaves*, or *Diapaſons*; when they were as 3 to 2, they called them *Fifths*, or *Diapentes*; if they were as 4 to 3, they call'd them *Fourths*, or Diateſſarons; if the Terms were as 5 to 4, they call'd it *Diton*, or *Tierce-Major*; but if the Terms were as 6 to 5, then they called it a *Demi-Diton*, or a *Tierce-Minor*; and laſtly, if the Terms were as 24 to 25, they called it a *Demiton*, or *Dieze*.

The Monochord being thus divided, was properly that which they called a *Syſtem*, of which there were many kinds, according to the different Diviſions of the Monochord.

Monotriglyph, a Term in Architecture, ſignifying the Space of one Triglyph between two Pilaſters, or two Columns.

Mood, in Muſick, ſignifies certain Proportions of the Time, or Meaſure of Notes. Theſe Moods or Modes, of meaſuring Notes, were formerly four in Number, *viz.*

1. *The Perfect of the More*, in which a Large contained three Longs, or a Long three Breves, a Breve three Semi-Breves, and a Semi-Breve three Minims.

2. *The Perfect of the Leſs*, wherein a Large comprehended two Longs, a Long two Breves, a Breve three Semi-Breves, and a Semi-Breve two Minims.

3. *The Imperfect of the More*, in which a Large contained two Longs, a Long two Breves, a Breve two Semi-Breves, and a Semi-Breve three Minims.

4. *The Imperfect of the Leſs*, is the ſame with that which we call the *Common Mood*, the other three being now altogether out of uſe; altho' the Meaſure of our common Triple-Time is the ſame with the Mood *Imperfect of the More*, except that we reckon but two Minims to a Semi-Breve, which in that Mood comprehended three. In our common Mood, two Longs make one Large, two Breves a Long, two Semi-Breves a Breve, &c. proceeding in the ſame Order to the laſt or ſhorteſt Note: So that a Large contains two Longs, four Breves, eight Semi-Breves, ſixteen Minims, thirty two Crotchets, ſixty-four Quavers, &c.

Be-

Besides these Moods of Time, five others relating to Tune, were in use among the ancient *Grecians*, which were termed Tones or Tunes by the *Latins*; the Design of either being to shew in what Key a Song was set, and how the different Keys had relation one to another.

These Sorts of Moods were distinguished by the Names of the several Provinces of *Greece*, where they were first invented; as the *Doric*, *Lydian*, *Ionic*, *Phrygian*, and *Æolic*.

Doric Mood consisted of slow-tuned Notes, and was proper for the exciting Persons to Sobriety and Piety.

Lydian Mood was likewise used in solemn grave Music; and the Descant or Composition was of slow Time, adapted to sacred Hymns or Anthems.

Ionic Mood was for more light and soft Musick; such as pleasant amorous Songs, Sarabands, Courants, Jigs, *&c*.

Phrygian Mood was a warlike kind of Musick, fit for Trumpets, Hautboys, and other Instruments of the like Nature, whereby the Minds of Men were animated to undertake Military Atchievements, or Martial Exercises.

Æolic Mood, being of a more airy, soft, and delightful Sound, such as our Madrigals, served to allay the Passions by the means of its grateful Variety, and melodious Harmony.

These Moods or Tones were distinguished into Authentic and Playal, with respect to the dividing of the *Octave* into its *Fifth* and *Fourth*.

The former was when the Fifth possessed the Lower Place, according to the harmonical Division of an *Octave*; and the other was when it stood in the Upper Place, according to the Arithmetical Division of the same *Octave*.

Month, properly speaking, is the Time in which the Moon runs through the *Zodiac*, and therefore is accounted by the Motion of the Moon: And so the *Lunar* Month is either Periodical, which is the Time of the Moon's Motion from any one Point of the *Zodiac* to the same again, and is something less than 27 Days and eight Hours; or else Synodical, which is the Time between New Moon and New Moon, and is something more than 29 Days and a half.

1. There is also a *Solar* Month, which is the Time that the Sun takes up in running through one of the Signs of the Zodiac, and is almost 30 Days and a half.

2. And both these *Solar* and *Lunar* Months, are either Astronomical, like those abovementioned; or Civil, which are various, according to the Usage of accounting in different Places, Cities, and Nations.

3. The *Egyptians* accounted by *Solar* Months, each of 30 Days; and to compleat their Year, after 12 such Months, they added five Days, which the odd Hours made up.

4. But most of the ancient Nations accounted by the Lunar Synodical Month; as the *Jews*, *Greeks*, and the *Romans*, till *J. Cæsar's* Time; and as the *Mahometans* do to this day. And because these Months did not contain an exact Number of Days, to adapt them to Civil Computation, they accounted alternately one Month to have 30, and the next 31 Days; and by this means they made two such Civil Months to be equal to two *Lunar* ones of 29 Days and a half: and they brought it to pass, that the New Month, for a Run of many Years, did not much deviate from the first Day of the Civil Month.

Moon. The Periodical Revolution of the Moon, in reference to the fixed Stars, is 27 Days, seven Hours,

Hours, 43 Minutes: And in the same Space of Time, by a strange Correspondence and Harmony of the two Motions, it revolves the same Way about its own Axis; whereby (one Motion converting it to, as the other turns it from the Earth) the same Side is always exposed to our Sight.

1. The Librations of the Moon's Body, which occasion that the same Hemisphere exactly is not always exposed to our Sight, arise from the Eccentricity of the Moon's Orbit, from the Perturbations by the Sun's Attraction, and from the Obliquity of the Axis of the Diurnal Rotation of the Moon's own Orbit, without the Knowledge of which Circumstances, her Phænomena would be inexplicable; but by the Consideration of them are very demonstrable.

2. The mean horary Motion of the Moon, in respect of the fixed Stars, is 32 Minutes, 56 Seconds, 27 Thirds, 12 Fourths and a half.

3. The Moon is distant from the Earth, according to most Astronomers, 59: According to *Vindeline*, 60; *Copernicus* $60\frac{1}{3}$: *Kircher*, $60\frac{1}{2}$: And according to *Tycho*, $56\frac{1}{2}$ Semidiameters of the Earth. Sir *Isaac Newton* thinks the Distance ought to be esteem'd about 61. Therefore the mean Distance may be reckon'd 60.

4. She is nearer the Earth at her Syzygy, than in the Quadrature by $\frac{1}{69}$th Part of the Distance.

5. According to Mr. *Cassini*, the Moon's greatest Distance from the Earth is 61, the mean Distance 56, and the least Distance 52 Semi-diameters of the Earth.

6. The Power of the Moon's Influence as to the Tides, is to that of the Sun as $6\frac{1}{3}$ to one. Sir *Isaac Newton*.

7. As to the Inequality of the Moon's Motion, (which proceeds from the Action of the Sun, disturbing the Motion of the secondary Planets) she moves swifter, and describes (by a Radius drawn from it to the Earth) a greater Area in proportion to the Time, hath an Orbit less curved, and by that means comes nearer to the Earth in her Syzygies or Conjunctions, than in the Quadratures, unless the Motion of her Eccentricity hinders it: Which Eccentricity is the greatest, when the *Apogæum* of the Moon happens in the Conjunction; and is least, when the *Apogæum* happens at the Quadratures; and her Motion is swifter also in the Earth's *Aphelion*, than in its *Perihelion*. The *Apogæum* also goes forward swifter in the Conjunction, and goes slower at the Quadratures; but her Nodes are at rest in the Conjunctions, and do recede most swiftly in the Quadratures.

8. The Moon also perpetually changes the Figure of her Orbit, or the Species of the Ellipsis she moves in.

9. There are also some other Inequalities in the Motion of this Planet, which can hardly be reduced to any certain Rule: As the Velocities or Horary Motions of the Apogæum and Nodes, and their Equations, and the Difference between the greatest Eccentricity in the Conjunctions, and the least in the Quadratures; and that Inequality which is called the *Variation of the Moon*: All these do increase and decrease annually, in a Triplicate Ratio of the apparent Diameter of the Sun: And this Variation is increased and diminished in a duplicate Ratio of the Time between the Quadratures; as Sir *Isaac Newton* proves in many Places of his *Principia*.

10. That curious Person found the Apogæum in the Moon's Syzygies

gies

gies to go forward 23 min. each Day, in respect of the fixed Stars; and to go backward 16 min. $\frac{1}{3}$ each Day in the Quadratures: And therefore the middle annual Motions he estimates at 40 Degrees.

11. That the Cause of the secondary Light of the Moon, as they call it, that is, the obscure Part of her appearing like kindled Ashes, just before and after the Change of the new Moon, is the Sun's Rays reflected from the bright Hemisphere of the Earth to those dark Parts of the Moon; and thence again reflected to the Earth destitute of the Sun's Light.

12. Sir *Isaac Newton* makes it a Proposition to enquire into the Figure of the Moon; and supposing it, at its first Original to have been a Fluid, like to our Sea, he calculates, that the Attraction of our Earth would raise the Water there to near 90 Foot high, as the Attraction of the Moon raiseth our Water to 12 Foot: Whence the Figure of the Moon must be a Spheroid whose greatest Diameter extended, will pass through the Centre of our Earth; and will be longer than the other Diameter perpendicular to it, by 180 Foot; and from hence it comes to pass, that we see always the same Face of the Moon: For she cannot rest in any other Position, but will continually endeavour to conform herself to this Situation, *Prop.* 38. *Lib.* III.

13. Mr. *Azout* says, that this Planet's Diameter never appear'd to him above 33 min. and never less than 24 min. 45 sec.

14. Sir *Isaac Newton* reckons the mean Diameter of the Moon to be 32 min. 12 sec. as the Sun's is 31 min. 27 sec.

15. The Density of the Moon he concludes to be to that of the Earth, as 9 to 5 nearly; and that the Mass or Quantity of Matter in the Moon to that of the Earth, is as 1 to 26 nearly.

16. The Plane of the Moon's Orbit is inclin'd to that of the Ecliptic, and makes with it an Angle of about five Degrees; and its Declination varies, and is greatest when the Moon is in the *Quadratures*, and least when she is in her *Syzygies*.

17. By means of the Spots in the Moon, the Lunar Ellipses are more accurately observed than formerly, to the great Advancement of Geography and Navigation in settling the Longitudes of Places; for the Immersion and Emersions of these Spots, from the Shadow of the Earth, are most nicely determined.

18. Although the Moon's Period round the Earth be in 27 Days, 7 Hours, and three Quarters, (which is the Periodical Month) yet because in the Space of a Periodical Month, the Earth also with its Satellite, the Moon, is moved forward almost an entire Sign; therefore the Point of the Moon's Orbit, in the last Conjunction, or New Moon, will be gotten too far to the Westward: and therefore the Moon cannot come yet to a new Conjunction with the Sun, but wants of it two Days and five Hours; which must be pass'd before the entire Lunation will be over, and before the Moon hath exhibited all her Phases. These two Days, and five Hours therefore being added to the Periodical Month, make the Synodical one, which consists of 29 Days, 12 Hours, and three Quarters.

19. The Moon disturbs the Motion of the Earth, and the common Centre of Gravity of those Bodies describe that Orbit about the Sun, which we have hitherto said that the Earth described; because we overlook'd the Action of the Moon; but the Earth really describes an irregular Curve.

20. The Gravity of the Moon towards the Earth, is increaſed by the Action of the Sun, when the Moon is in the *Quadratures*; and it is an Augmentation or Addition to the Gravity of the Earth towards the Sun.

21. The Earth's Diſtance from the Sun remaining the ſame, the abovemention'd Addition of Gravity increaſes and diminiſhes in the Ratio of the Diſtance of the Moon from the Earth.

22. The Diſtance of the Earth from the Sun remaining the ſame, the Gravity of the Moon towards the Earth decreaſes more ſlowly in the *Quadratures*, than according to the inverſe Ratio of the Square of the Diſtance from the Centre of the Earth.

23. The Force which diminiſhes the Gravity of the Moon in the *Syzygies*, is double that which increaſes it in the *Quadratures*.

24. In the *Syzygies*, the diſturbing Force is directly as the Diſtance of the Moon from the Earth, and inverſly as the Cube of the Diſtance of the Earth from the Sun.

25. At the *Syzygies* the Gravity of the Moon towards the Earth, receding from its Centre, is more diminiſhed, than according to the inverſe Ratio of the Square of the Diſtance from that Centre.

26. In the Motion of the Moon from the *Syzygies* to the *Quadrature*, the Gravity of the Moon towards the Earth is continually increaſed, and the Moon is continually retarded in its Motion: But in the Motion from the *Quadrature* to the *Syzygy*, every Moment the Moon's Gravity is diminiſhed, and its Motion in its Orbit is accelerated.

27. As the Radius is to the Sine, and an half of double the Diſtance of the Moon from the *Syzygy*; ſo the Addition of Gravity in the *Quadratures*, is to the Force which accelerates or retards the Moon in its Orbit.

28. And the Radius is to the Sum or Difference of one and a half, the Co-Sine of double the Diſtance of the Moon from the *Syzygy*, and half the *Radius*; as the Addition of Gravity in the *Quadratures*, to the Diminution or Increaſe of Gravity in that Situation of the Moon, concerning which the Computation is made.

29. The Moon is leſs diſtant from the Earth at the *Syzygies*, and more at the *Quadratures*.

30. In the *Quadratures* and *Syzygies*, the Moon deſcribes *Area's* by Lines drawn to the Centre of the Earth, proportional to the Times.

31. The *Area's*, by Lines drawn to the Centre of the Earth, are not exactly proportional to the Times at all Times.

32. The Apſides of the Moon go forward, when the Moon is in the *Syzygies*: In the *Quadratures*, the Apſides go backwards, that is, move *in Antecedentia*.

33. The Progreſs, conſidering one entire Revolution of the Moon, exceeds the Regreſs, *Cæteris Paribus*.

34. The Apſides go forward faſteſt of all in a Revolution of the Moon, ſuppoſing the Line of the Apſides in the Nodes; and in that very Caſe they go back the ſloweſt of all in the ſame Revolution.

35. Suppoſing the Line of the Apſides to be in the *Quadratures*, the Apſides are carried *in Conſequentia*, the leaſt of all in the *Syzygies*; but they return the ſwifteſt in the *Quadratures*; and in this Caſe, in one entire Revolution of the Moon, the Regreſs exceeds the Progreſs.

36. The Excentricity of the Orbit, every Revolution undergoes various Changes. It is the greateſt of

of all, when the Line of the Apsides is in the *Syzygies*; but the Orbit is the least Excentric of all, when the Line of the Apsides is in the Quadratures.

37. The Ratio between the Addition of Gravity in the *Quadratures*, and the Force, which removes the Moon out of its Orbit, is the Ratio of the Cube of the Radius to three times the Product of the Sines of the Distances of the Moon from the *Quadrature*, and of the Node from the *Syzygy*; as also of the Inclination of the Plane.

38. This Force is increased as the Moon advances towards the *Syzygy*, and as the Nodes recede from it.

39. Considering one entire Revolution of the Moon, *Cæteris Paribus*, the Nodes move *in Antecedentia* swiftest of all, when the Moon is in the *Syzygies*; then slower and slower, till they are at rest, when the Moon is in the *Quadratures*.

40. The Line of Nodes does successively acquire all possible Situations in respect of the Sun; and every Year goes twice thro' the *Syzygies*, and twice thro' the *Quadratures*.

41. If we consider several Revolutions of the Moon, the Nodes in one whole Revolution go back very fast, the Nodes being in the *Quadratures*; then slower, till they come to rest, when the Line of Nodes is in the *Syzygies*.

42. By the same Force with which the Nodes are moved, the Inclination of the Orbit is also changed; it is increased as the Moon recedes from the Node, and diminished as it comes to the Node.

43. When the Nodes are come to the *Syzygies*, the Inclination of the Plane of the Orbit is the least of all; for in the Motion of the Nodes from the *Syzygies* to the *Quadratures*, and in one whole Revolution of the Moon, the Force which increases the Inclination exceeds that which diminishes it; therefore the Inclination is increased, and it is the greatest of all, when the Nodes are in the *Quadratures*.

44. All the Errors in the Moon's Motion are something greater in the Conjunction than in the Opposition.

45. All the disturbing Forces are inversly, as the Cube of the Distance of the Sun from the Earth, which when it remains the same, they are as the Distance of the Moon from the Earth. Considering all the disturbing Forces together, the Diminution of Gravity prevails.

46. The Motion of the Moon being considered in general. The Gravity of the Moon towards the Earth is diminished coming near the Sun, and the Periodical Time is the greatest; as also the Distance of the Moon (*Cæteris Paribus*) the greatest, when the Earth is in the *Perihelion*.

MORTAR-PIECE, is a kind of very short Piece of Cannon, or Ordnance, thick and wide, proper for the discharging of Bombs, Carcasses, Stones, *&c.* It is usually mounted on a Carriage, the Wheels whereof are very low.

Mr. Anderson's TABLE *of the requisite Weight of Powder for all Mortars, from 6 to 20 Inches diameter.*

Inch.	*Decim.*	*Pounds.*	*Ounces.*
6.	0	0.	13
6.	5	1.	01
7.	0	1.	05
7.	5	1.	10
8.	0	2.	00
8.	5	2.	06
9.	0	2.	14
9.	5	3.	06
10.	0	3.	$14\frac{1}{2}$

10.

Inch.	*Decem.*	*Pounds.*	*Ounces.*
10.	5	4.	08
11.	0	5.	03
11.	5	5.	15
12.	0	6.	12
12.	5	7.	10
13.	0	8.	09
13.	5	9.	10
14.	0	10.	$11\frac{1}{2}$
14.	5	11.	14
15.	0	13.	03
15.	5	14.	09
16.	0	16.	16
16.	5	17.	09
17.	0	19.	03
17.	5	20.	15
18.	0	22.	$12\frac{1}{2}$
18.	5	24.	11
19.	0	26.	13
19.	5	23.	14
20.	0	31.	04

See the Description of Mortars by *Methins*, in his *Artiller. part* 3. *c.*18, and foll. And *Buckner*'s *Artill. part.* 1. *f.* 78. *& seq.* As also *Surire de Saint Remy*'s *Memoires d'Artillerie, Part* 2. *p.* 352 *& seq.*

MOTION, is a Continual and Successive Mutation of Place, and is either Absolute or Relative.

1. *Absolute Motion*, is the Change of the *Locus Absolutus* of any moving Body, and therefore, its Celerity will be measured by the Quantity of the absolute Space, which the moveable Body has run through. But,

2. *Relative Motion*, is the Mutation of the Relative or Vulgar Place of the moving Body, and so hath its Celerity accounted or measured by the Quantity of relative Space, which the moveable Body runs over.

3. All Motion is of itself Rectilinear, or made according to straight Lines, with the same constant uniform Velocity; if no external Cause makes any Alteration in its Direction.

4. If two Bodies, moving uniformly, go with unequal Velocities, the Spaces which will be pass'd over by them in unequal Times, will be to one another in a Ratio compounded of that of the Velocities, and that of the Times.

5. The Motions of all Bodies are as the Rectangles under the Velocities, and the Quantities of Matter.

6. The Motions of Bodies included in a given Space, among themselves, will not be changed by the Motion of that Space uniformly forwards in a straight Line.

7. Every Body will continue in its State, either of Rest or Motion, uniformly forward in a Right Line, unless it be made to change that State by some Force impressed upon it.

8. The Change of Motion is proportionable to the moving Force impressed, and is always according to the Direction of that Right Line, in which the Force is impressed.

9. The Quantity of any Motion is discoverable by the Joint-Consideration of the Quantity of Matter in, and the Velocity of the moving Body: For the Motion of any Whole, is the Sum of the Motions of all the Parts.

10. The Quantity of Motion, which is found, by taking either the Sum of Motions made the same Way, or the Difference of those which are made contrary Ways, is not at all changed by the Action of Bodies one upon another.

11. In all kind of Motions whatever, rolling, sliding, uniform, accelerated, or retarded, in right Lines, or in Curves, *&c.* the Sum of the Forces which produce the Motion of all Parts of its Duration, is always proportionable to the Sum of the Paths, or Lines, which all the Points of the moving Body describe.

12. The Product of the Duration of all uniform Motions, multiplied by the Force which began the Motion, is always proportionable to the Product made by the Path, or Line of Motion multiplied by the Mafs or Quantity of Matter in the moving Body.

Motion *of the Apogæum*, in the *Ptolemaic* Syftem, is an Arch of the *Zodiac* of the *Primum Mobile*, contained between the Line of the *Apogæum*, and the beginning of *Aries*.

Motion Compounded. See *Compound Motion*.

Mouldings. Under this Name are comprehended all thofe Jettings or Projectures beyond the naked Wall, a Column, *&c.* which only ferve for Ornament; whether they be fquare, round, ftraight or crooked. Of thefe there are feven kinds more confiderable than the reft, *viz.* the *Doucine*, the *Taton* or *Heel*, the *Ovolo* or *Quarter-Round*, the *Plinth*, the *Aftragal*, the *Denticle*, and the *Cavetto*.

Movement; the fame with what many do call an *Automaton*, and with us fignifies all thofe Parts of a Watch, Clock, or any fuch curious Engine, which are in Motion, carry on the Defign, or anfwer the End of the Inftrument.

Moulinet, a *French* Term, fignifying a Turn-Stile; 'tis ufed in Mechanics, and fignifies a *Roller*, which being croffed with two Levers, is ufually applied to Cranes, Capftans, and other Sort of Engines of the like Nature, to draw Cords, and heave up Stones, Timber, *&c.* Alfo a kind of Turn-Stile, or wooden Crofs, which turns horizontally upon a Stake fixed in the Ground, and is ufually placed in Paffages, to keep out Horfes, and to oblige Paffengers to go, or come one by one.

Thefe Moulinets are often fet up near the Out-Works of fortified Places, at the Side of the Barriers, through which People pafs on Foot.

Moyenau, (a *French* Term) in Fortification, is a fmall flat Baftion, commonly placed in the middle of an over-long Curtain, by which the Baftions at the Extremities are not well defended from the Small-Shot, by reafon of their Diftance; fo that this Work is proper for placing in it a Body of Mufqueteers to fire upon the Enemy from all Sides.

Multangular Figure, is one that has many Sides and Angles.

Multilateral, in Geometry, are thofe Figures that have more than four Sides.

Multinomial Root. See *Polynomial*.

Multiple Proportion, is when the Antecedent being divided by the Confequent, the Quotient is more than Unity; and the Reafon of the Name is, becaufe the Confequent muft be multiplied by the Index, or Exponent of the Ratio, to make it equal to the Antecedent. Thus 12 is multiple in proportion to 4, becaufe being divided by 4, the Quotient is 3, which is the Denominator of the Ratio; and the Confequent 4 being multiplied by 3, makes the Antecedent 12; wherefore 3 is fub-multiple of 12.

Multiple Super-Particular Proportion, is when one Number or Quantity contains another more than once, and fuch an aliquot Part.

Multiple Super-Partient Proportion, is when one Number or Quantity contains another divers Times, and fome Parts befides.

Multiplication, is, in general, the taking or repeating of one Number or Quantity as often as there are fuppofed Units in the other Number: The Number multiplied, is called the *Multiplicand*, the Number multiplying, the *Multiplicator*;

tiplicator or *Multiplier*; and that which is found or produced, is called the *Product*.

Multiplication, is only a compendious Addition, effecting at once, what in the ordinary Way of Addition would require many Operations: For the Multiplicand is only added to itself, or repeated, as often as the Units of the Multiplicator do express it. Thus if 6 were to be multiplied by 4, the Product is 24, which is the Sum arising from the Addition of 6 four times to itself.

In all Multiplication, as 1 is to the Multiplicator; so is the Multiplicand to the Product.

1. Multiplication of whole Numbers is perform'd by the following Rules. If the Multiplier be less than 10, set it under the first Figure of the Multiplicand, and having drawn a Line underneath, let each Figure thereof, beginning at the place of Units, be multiplied by the Multiplier, and set each single Product (if less than 10) under its respective Figure of the Multiplicand; but if it be 10, or any Number of 10's with some Over plus, subscribe that Over-plus; but if without, set down a Cipher, and always for every 10, reserve 1 to be added to the next Product, and the Number subscribed will be the Product of the whole.

When the Multiplier consists of several Figures, let the Multiplicand be multiplied by each Figure of the Multiplier, as before, beginning with the first, and placing the several Products thereof underneath each other in such order, that the first Figure or Cipher of each Product may be in the same place (of Units, Tens, &c.) with its respective multiplying Figures; then add these particular Products together, and the Sum of them will be the Product of the whole Multiplication.

Examples,

```
  9764
     3
 -----
 31292

   5326   Multiplicand
    427   Multiplier
 -------
  37282
 10652
21304
 -------
2274202   Product.
```

The Reason of these Rules depends upon the following Proposition, *viz.* that the Product of any two Numbers is equal to the several Products made by multiplying all the Parts of the one, by the other, or all the Parts of the other.

2. To multiply a Fraction by a Fraction, is to take the Multiplicand so many such Parts of a Time as is signified by the Multiplier; to do which, multiply the Numerators of the two Fractions together, for the Numerator of the Fraction desired, and their Denominators for the Denominator of the Fraction, which is the Product of the two given Fractions; as $\frac{2}{5}$ multiplied by $\frac{3}{7}$ is $\frac{2 \times 3}{5 \times 7}$ or $\frac{6}{35}$; and the Product will be always less than either of the Fractions multiplying each other.

3. The Multiplication of Decimal Fractions, is the same with that of whole Numbers, only in the Product there must be always as many Decimal Places, as are both in the Multiplier and Multiplicand. Examples:

```
Multiplicand  759.2
                5.037
              --------
                53144
               22776
              37960
              --------
Product       3524.0904
```

 .0096

$$\begin{array}{r} .0096 \\ .072 \\ \hline 192 \\ 672 \\ \hline .0006912 \end{array}$$

$$\begin{array}{r} .45 \\ .029 \\ \hline 405 \\ 90 \\ \hline .01305 \end{array}$$

4. Multiplication in Algebra, is performed when the Quantities are simple, by an immediate joining of the Letters, or if the simple Quantities have Numbers before them, by setting the Product of the Multiplication of those prefixed Numbers, before the Letters thus joined; as a multiplied by b is ab, aa multiplied by cd, is $aacd$; $5e$ multiplied by $7gc$, is $35egc$; and so of others. But if the Quantities to be multiplied be Compound, then every simple Quantity in the Multiplication is to be multiplied by each simple Quantity of the Multiplier, and the Signs $+$ and $-$ must be set between the several Products, always observing to prefix the Sign $+$ to that Product arising from the Multiplication of two simple Quantities having both the Sign $+$ prefix'd, or both the Sign $-$; and to prefix the Sign $-$ to the Product, when the Signs of the simple Quantities are different; for Example, $a+e$ multiplied by b, will produce $ab+eb$; $a-e$ multiplied by b, will be $ab-eb$; $a+e+c$ multiplied by z will be $az+ez+cz$: Also $ac-bd+ef$ multiplied by $g+h-k$ will give $acg-bdg+gef+ach-bdh+efh-ack+bdk-efk$.

Multiplicand, in Arithmetic, is the Number to be multiplied.

Multiplicator, in Arithmetic, is the Number by which you multiply, or the Number multiplying.

Multiplier, the same with *Multiplicator*.

Murderers, are small Pieces of Ordnance, either of Brass or Iron, having Chambers (that is, Charges made of Brass or Iron) put in at their Breeches: They are mostly used at Sea, at the Bulk-Heads of the Fore-castle, Half Deck, or Steerage, in order to clear the Decks, when any Enemy boards the Ship; they are fasten'd and travers'd by a Pintle, which is put into a Stock.

Music, is one of the seven Sciences, commonly called *Liberal*, and comprehended also among the Mathematical, as having for its Object discrete Quantity or Number; but not considering it in the Abstract like Arithmetic; but with relation to Time and Sound, in order to make a delightful Harmony.

This Science is also Theoritical, which examineth the Nature and Properties of Concords and Discords, explaining the Proportions between them by Numbers: And Practical, which teacheth not only Composition, that is, the manner of composing all Sorts of Tunes, or Airs; but also the Art of Singing with the Voice, or Playing upon Musical Instruments.

Some of the Ancients who have wrote of Harmony, are *Aristoxenus*, *Euclid*, *Plutarch*, *Ptolemy*, *Psellus*, *Porphyry*, *Briennius*, *Nichomachus*, *Alipius*, *Gaudentius*, *Bacchius*, *Quintilian*, *Cassiodorus*, *Capella*, *Boetius*, *Proclus*, &c. And some of the Moderns are *Meibomius*, *Wallis*, *Descartes*, *Mersennus*, *Faber*, *Holder*, *Sauveur* (in the *French Memoires*, An. 1701, 1707, 1711,) *Dechales* (in his 4 tom. *Mundi Mathematici*,) M. *Perault*, Mr. *Malcolme*, Mr. *Remeau*, Mr. *Euler*, &c.

It

It is very easy to conclude, from what we have upon Music from the Ancients, that it was very imperfect and deficient; and notwithstanding the fabulous Wonders, it is said to produce upon Men's Passions in those times, yet now-a-days I believe, the most skilful of their Musicians would little or scarcely move one at all: for it is mostly agreed, that the ancient *Greeks* had not the Use of Concert Music, *viz.* of different Parts sounding at once, but only solitary, for one single Voice or Instrument; or else the same Piece sung or sounded by several Voices or Instruments together; but some Octaves, or perhaps Fifths above the others. *Guido Aretinus* is said to be the first who invented and brought Symphony or Concert into Music; but what Progress he made, and what were his Compositions, we do not know. In a word, one may venture to affirm from the whole of what we find wrote on the Subject, that Music did not begin to arrive at any tolerable Perfection, till towards the End of the last Century, when the great *Purcel* and prodigious *Corelli* oblig'd the World with their most agreeable and harmonical Compositions; then it was that Music began to advance apace, and receive great Improvements from many other ingenious Composers and Performers of several *European* Nations, especially the *Italians* and *English*, and now seems to be brought near its utmost Perfection; since all the agreeable Combinations of the various Continuance, Rising, Falling, and Mixtures of Tones, must be contain'd within certain Limits, whose Number may not be so great as is generally imagined; and because of the great Number of Persons who have for more than thirty Years last past, applied themselves to this Art. Among whom the excellent Mr. *Handel* himself, deservedly named the Prince of Musicians, both for his Composition and Execution upon the Organ and Harpsicord, has abundantly and wonderfully performed his part.

Musket-Baskets, in Fortification, are Baskets of about a Foot and a half high, and eight or ten Inches diameter at the bottom, and a full Foot at the top: They are filled with Earth, and are set on low Parapets, or Breast-Works, or on such as are beaten down, that the Musqueteers may fire between them at the Enemy, and yet be tolerably well secured against their Fire.

Mutule, in Architecture, is a kind of square Modilion, set under the Cornice of the *Doric* Order, and so called from the Word *Mutilus*, maimed or imperfect, because they represent the Ends of the Rafters, which are crooked or bent, in like manner, as the Beams or Joints are represented by the Triglyphs in the Frize of the same Order.

N.

NADIR is that Point of the Heavens under the Earth, which is diametrically opposite to the Point directly over our Head, *viz.* the *Zenith*; so that they are both as it were the Poles of the Horizon, and distant from it on each side ninety Degrees, and consequently fall upon the Meridian, one above the other under the Earth; and whatever Distance one of them has from the Equator, and one of the Poles of the World, the same, on the contrary, has the other from the opposite Pole and adverse Part of the Equator.

Napiers, or Naper's-Bones, or Rods, are a kind of larger Multiplication-Table, contriv'd upon four-

four-square Wooden or Ivory Rods by the Lord *Napier*, for the more easy multiplying, dividing, and extracting the Roots of great Numbers.

NATURAL DAY. See *Day*.

NATURAL HORIZON; the same with *Sensible Horizon*.

NATURAL PHILOSOPHY, is the same with what is usually called *Physics*, *viz.* that Science which contemplates the Power of Nature, the Properties of natural Bodies, and their mutual Actions one upon another.

NAVIGATION, is the Art of Sailing, whereby the Mariner is instructed how to guide a Ship from one Port to another, the shortest and safest way, and in the shortest time: And this is two-fold, either

Improper, which is called *Coasting*, in which the Places are at no great distance one from another, and the Ship sails usually in sight of Land, and is within Soundings. Now, for the Performance of this, there is required a good Knowledge of the Lands, the Use of the Compass, the Lead, or Sounding Line, and such Books as *Rutter's*, &c.

Proper, is where the Voyage is performed in the vast Ocean, out of sight of all Land; and here is necessary not only the Knowledge of the Lead, Compass, *&c.* But the Master must be a thorough Sailor or Artist, and understand well *Mercator's Charts*, *Azimuth*, and *Amplitude Compass*, *Log-Line*, and all good Instruments for Celestial Observations that can be used at Sea.

Some of the Writers upon Navigation, are *Varenius*, *Wright*, *Norwood*, *Newhouse*, *Seller*, *Ricciolus*, *Hodgson*, *Jones*, *Atkinson*, *Harris*, *Patoun*, &c.

NAUTICAL CHART, the same as *Sea-Chart*.

NAUTICAL COMPASS, the same as *Sea-Compass*.

NAUTICAL PLANISPHERE, is a Description of the Terrestrial Globe upon a Plane, for the Use of Mariners; and is either the *Plane Chart*, as they call it, where the Parallels of Latitude are all of the same Length with the Meridians; and which therefore is very erroneous, except in short Voyages, and near the Equator: Or *Mercator's Chart*, where the Meridians are increased in proportion, as the Parallels shorten, that is, as the Secants of the Arch contained between the Point of Latitude, and the Equator.

NEBULOUS STARS, are certain fixed Stars of a dull, pale, and obscurish Light. These seen through good Telescopes, appear to be Clusters of small Stars.

NEEDLE. See *Box and Needle*.

NEGATIVE QUANTITIES, in Algebra, are such as have before them the Negative Sign, and which are supposed to be less than nothing.

NEIPE TIDES, *written also* NEPE *or* NEEP, are those Tides (when the Moon is in the middle of the second and last Quarter) which are opposite to the Spring-Tides; and as the highest of the Spring-Tides is three Days after the Full or Change, so the lowest of the Neep is four Days before the Full or Change.

NEWEL, in Architecture, is the upright Post that the Case of Winding-Stairs turns round about.

NICHE, in Architecture, is a Cavity left designedly in the Wall of a Building, to place a Statue in.

NOCTURNAL, is an Instrument made of Box, Ivory, or Brass, to take the Altitude or Depression of the Pole-Star, in respect to the Pole itself, in order to find the Latitude, and nearly the Hour of the Night.

1. There are several Sorts of Nocturnals, of which some may be Projections

jections of the Sphere; such as the Hemispheres or Planispheres on the Plane of the Equinoctial; but the Seamen use only two, and the manner of using either is the same. One of them is fitted for the *Pole-Star*, and first of the Gardes of the *Little Bear*; and the other for the *Pole-Star*, and the Gardes or Pointers (as some call them) of the *Great Bear*.

2. The Instrument consists of three Parts or Pieces; the largest of which hath a Handle to hold it by, when you would observe; and opposite to the Handle, there is a small Tooth or Point, which (if it be made for the *Little Bear*) stands against the 25th of *April*; but if for the *Great Bear* against the 17th of *February*, which are the Times of the Year when those Stars come to the Meridian at Twelve at Night. On this bigger Part or Piece there are two Circles described; the outermost hath the Months and their Days, and the innermost hath the 24 Hours of a natural Day. On the backside of this Piece also are 32 Points of the Compass designed and marked, and their intitial Letters.

3. The second Part of the Nocturnal hath two Circles described on it; of which the outermost is divided into 29½, equal Parts for the Days of the Moon's Age, and the innermost into 24 Hours; and at the Beginning of the Days of the Moon's Age, and at Twelve there is a Tooth to be set to the Day of the Month in the upper Part.

4. The third Part is an Index with a fiducial Edge, issuing from the Centre; and must be so long, that a good Part of it may extend beyond the outermost or biggest Piece. These three Parts are so order'd, that by means of a small hollow Brass Socket they are made to move about the Centre of the Instrument.

NOCTURNAL ARCH, is that Space in the Heavens which the Sun, Moon, or Stars, runs thro' parallel to the Equator, from their Setting to their Rising.

NOCTURNABLE, is an Instrument used to find how much the North Star is higher or lower than the Pole at all Hours of the Night.

NODATED HYPERBOLA. So Sir *Isaac Newton* calls a *peculiar kind of Hyperbola*, which by turning round decussates, or crosses itself. See Sir *Isaac Newton*'s *Tractatus de Enumeratione Linearum tertii Ordinis*.

NODES, in Astronomy, are the Points of the Intersection of the Orbit of the Sun, or any Planet, with the Ecliptic; so that the Point where a Planet passes over the Ecliptic, out of Southern into Northern Latitude, is called the *North* or *Ascending Node*. And where it descends from North to South, 'tis the *South* or *Descending Node*.

NODUS, or NODE, in Dialling, is a certain Point in the Axis or Cock of a Dial, by the Shadow of which, either the Hour of the Day in Dials without Furniture, or the Parallels of the Sun's Declination, his Place in the Ecliptic, the *Italian* or *Babylonish* Hours, *&c.* are shewn in such Dials as have Furniture.

NONAGESIMAL DEGREE, is the highest Point, or 90th Degree of the Meridian.

NONES *of a Month*, are the next Days after the Kalends, which is the first Day in *March*, *May*, *June*, and *October*; the *Romans* accounted six Days of the Nones; but in all the rest of the Months but four. They had this Name probably, because they were always nine Days inclusively, from the first of the Nones

to the Ides, *i. e.* reckoning inclusively both those Days.

NORMAL, the same with *Perpendicular*, or at *Right Angles*; and 'tis usually spoken of a Line, or a Plane that intersects another perpendicularly.

NORTHERN SIGNS *of the Ecliptic or Zodiac*, are those six which constitute that Semi-circle of the Ecliptic, which inclines to the Northward from the Equator; as *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*.

NOTES, in Music, are certain Terms invented to distinguish the Degrees of Sound, and the Proportion of Time belonging to it.

1. These Notes relating to the Distinctions of Sound, are seven in number, *viz. Gamut*, *Aire*, *Bemi*, *Cefaut*, *Gesolrate*, *Alamire*, *Befabemi*, *Cesolfaut*.

2. And the Notes relating to Time, are nine in Number, *viz.* a *Large*, *Long*, *Breve*, *Semi-Breve*, *Minim*, *Crotchet*, *Quaver*, *Semi-Quaver*, and *Demi-Semi-Quaver*.

3. But the *Large* and *Long* are now of little Use, as being too long for any Voice or Instrument (the Organ only excepted) to hold out to their full Length; although their Rests are still very often used, more especially in grave Music, and Songs of many Parts.

NUCLEUS, is by *Hevelius* and others used for the Head of a Comet, and by others for the central Parts of any Planets.

NUCLEUS, in Architecture, is the middle Part of the Flooring of the Antients, consisting of Cement, which they put betwixt a Lay, or Bed of Pebbles, cemented with Mortar made of Lime and Sand.

NUMBER, is whatever is referr'd to Unity; or it is a Collection of Units, and is that which teacheth us to know how many any of the Objects of our Knowledge are.

NUMERATION, in Arithmetic, is the true Distinction, Estimation, and Pronunciation of Numbers, or the Rule to read any Number, tho' never so great, and to have a distinct Idea of each Place or Figure of it.

NUMERATOR *of a Fraction*, is that Part of it which shews or numbers how many of those Parts which any Integer is supposed to be divided into, are expressed by the Fraction. Thus in $\frac{6}{8}$, 6 is the Numerator, (which stands always above the Line) and shews you, that if any Whole be divided into 8 Parts, you number and enumerate, or take 6 of them, *i. e.* three Quarters.

O.

OBELISK, in Architecture, is a kind of quadrangular Pyramid, very tall and slender, raised in a public Place, to shew the Largeness of some enormous Stone, or to serve as a Monument of some memorable Transaction.

OBJECT-GLASS, of a Telescope or Microscope, is that Glass which is placed at that End of the Tube, which is next the Object.

OBJECTIVE-LINE. See *Line-Objective*.

OBLIQUE ANGLES. See *Angles Oblique*.

OBLIQUE ASCENSION, is that Degree and Minute of the Equinoctial which riseth with the Centre of the Sun or Star, or with any Point of the Heavens, in any oblique Sphere.

OBLIQUE CIRCLE, in the Stereographical Projection of the Sphere, is any Circle that is Oblique to the Plane of Projection.

OBLIQUE DESCENSION, is that Part of the Equinoctial which sets with the Sun or Star, or with any Point of the Heavens, in an oblique Sphere.

Oblique Force, is that whose Line of Direction is not at Right Angles with the Body on which it is imprest. The Ratio which such an oblique Force, to move a Body, bears to a direct or perpendicular Force, will be as the Sine of the Angle of Incidence is to the Radius.

Oblique Plains, in Dialling, are such as recline from the Zenith, or incline to the Horizon.

Oblique Sailing, is the Application of the Method of calculating the Parts of oblique Plane Triangles, in order to find the Distance of a Ship from any Cape, Head-Land, *&c.*

Oblique Sphere, is where the Pole is elevated any Number of Degrees less than 90 Degrees, and consequently the Axis of the World, the Equator, and Parallels of Declination, will cut the Horizon obliquely.

Oblong, in Geometry, is the same with a Rectangle-Parallelogram, whose Sides are unequal.

Obscura Camera. See *Camera Obscura.*

Observation. The Seamen call an Observation the taking the Sun or any Star's Meridian Altitude, in order thereby to find their Latitude; and how they do this, you will find under that Word: And they call finding the Latitude, by the Name of *Working an Observation.*

Obtuse Angles. See *Angles.*

Obtuse Angular *Section of a Cone.* So the ancient Geometers called that *Conic Section*, which since, by *Apollonius*, is called the *Hyperbola*, because they considered it only in such a Cone, whose Section through the Axis is a Triangle, obtuse-angled at the Vertex.

Obtuse-Angled Triangle, is one that has an obtuse Angle.

Occidental, *(i. e. Westward)* in Astronomy, a Planet is said to be Occidental, when it sets after the Sun.

Occultation, in Astronomy, is the Time that a Star or Planet is hid from our Sight, when eclipsed by the Interposition of the Body of the Moon, or some other Planet between it and us.

Ocean, is by Geographers taken for that great Collection of Waters, or large Sea, which compasses in the whole Earth, and into which the other lesser Seas do usually run.

1st, This great and universal Ocean, is sometimes by Geographers divided into three Parts. As, 1. The *Atlantic* and *European* Ocean, lying between Part of *Europe*, *Africa*, and *America*. 2. The *Indian* Ocean, lying between *Africa*, the *East-Indian* Islands, and *New-Holland*. 3. The great *South-Sea*, or the *Pacific* Ocean, which lies between the *Philippine* Islands, *China*, *Japan*, and *New-Holland* on the West, and the Coast of *America* on the East.

2dly, The Surface of the whole Ocean, or of all the Seas of the Globe, Mr. *Keil* computes, in his Examination of Dr *Burnet*'s *Theory of the Earth*, to be 85490506 square Miles; and therefore supposing the Depth to be a Quarter of a Mile, the Quantity of Water in the whole is $21372626\frac{1}{2}$ cubic Miles.

Octagon, in Geometry, is a Figure of eight Sides and Angles: And this, when all the Sides and Angles are equal, is called a *Regular Octagon*, or one which may be inscribed in a Circle.

If the Radius of a Circle circumscribing a Regular Octagon be $= r$, and the Side of the Octagon $= y$; then $y = \sqrt{2r^2 - r\sqrt{2r^2}}$.

Octahedron, is one of the regular Solids, consisting of eight equal and equilateral Triangles.

The Square of the Side of the *Octahedron*, is to the Square of the Diameter

Diameter of the circumſcribing Sphere, as 1 to 2.

If the Diameter of the Sphere be 2, the Solidity of the *Octahedron* inſcribed in it, will be 1,33333, nearly.

Octave, *or* Eighth, in Muſic, is an Interval of eight Sounds; every Eighth Note in the Scale of the Gamut being the ſame, as far as the Compaſs of Muſick requires.

Octostyle, in Architecture, is the Face of an Edifice adorn'd with eight Columns.

Ogee. See *Cima*.

Opacous Bodies, are thoſe thro' which the Rays of Light have no Admiſſion.

Sir *Iſaac Newton* in his *Optics*, *Book* II. ſhews, That the Opacity of all Bodies ariſeth from the Multitude of Reflexions cauſed in their internal Parts: And he ſhews alſo, that between the Parts of the Opake, and coloured Bodies, there are many Spaces, either empty or repleniſhed with Mediums of other Denſities; and he ſhews the true or principal Cauſe of Opacity to be this Diſcontinuity of their Parts; becauſe ſome Opake Bodies become tranſparent by filling their Pores with any Subſtance of equal Denſity with their Parts.

Open Flank, in Fortification, is that Part of the Flank which is covered by the Shoulder or Orillion.

Opening *of the Trenches*, is the firſt breaking Ground of the Beſiegers, in order to carry on their Attacks againſt the Town.

Ophiucus. One of the Northern Conſtellations, containing thirty Stars.

Opposite Angles. See *Angles*.

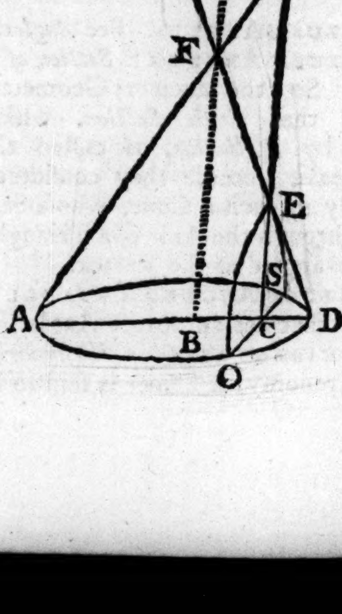
Opposite Cones, are two Similar Cones, as A, B, having the ſame common Vertex G, and alſo the ſame Axis.

Opposite Sections, are the Hyperbola's D, C, made by cutting

the Oppoſite Cones A, B, by the ſame Plane. Theſe Hyperbola's are always equal and ſimilar.

If the oppoſite Superficies be cut by a Plane making the oppoſite Hyperbola's (or Sections) O E S, *o* G *e*: I ſay, both thoſe Hyperbola's will be perfectly alike and equal.

Let A F D be the Triangle paſſing thro' the Axis at Right Angles to the Plane of the Hyperbola O E S, and ſuppoſe L F I to be a



Tri-

Triangle, in the ſame Plane as the Triangle AFD; this ſhall paſs thro' the Axis of the oppoſite Cone, and will cut the Hyperbola *o* G *e* at Right Angles. Let A D, and L I, be parallel common Sections of thoſe Triangles, and the Baſes of the oppoſite Cones. Draw the Right Line KFB thro' the Vertex F, in the Plane of the Triangles, parallel to the common Diameter GE of the Oppoſite Sections. Now, our Buſines is to prove, that $LH \times HI$ $(= \overline{oH}^2) : AC \times CD\ (= \overline{OC}^2) :: HE \times GH : GC \times EC$.

Becauſe the Triangles ABF, ACG, and DBF, DCE, are ſimilar. We have $AB : BF :: AC : CG$, and $BD : BF :: CD : EC$; therefore $AB \times BD : \overline{BF}^2 :: AC \times CD : CG \times EC$, by multiplying the Antecedents and Conſequents of both Proportions by each other.

Again, becauſe the Triangles ABF, IHG, and BDF, HLE, are ſimilar, therefore $AB : BF :: HI : HG$; $BD : BF :: LH : HE$. And ſo multiplying the Antecedents and Conſequents of both the Proportions by one another, and you will have $AB \times BD : BD : \overline{BF}^2 :: HI \times LH : HG \times HE$. But it was prov'd before that $AB \times BD : \overline{BF}^2 :: AC \times CD : CG \times EC$. Therefore $HI \times LH : HG \times HE :: AC \times CD : CG \times EC$, and ſo $HI \times LH : AC \times CD :: HG \times HE : CG \times EC$.

Opposition, is that Poſition or Aſpect of the Stars or Planets, when they are 6 Signs, or 180 Degrees diſtant from one another, and is marked thus, ☍.

Opticks, taken properly and ſimply, is that Science which teaches the Properties of a direct Viſion; but in a larger Senſe it may comprehend the whole Doctrine of Light and Colours, and all the Phænomena of viſible Objects.

Euclid long ago wrote of Optics, but with no great Skill. See Dr. *Gregory*'s *Euclid*, and *Herigon*'s *Curſus Mathemat.* ſo did *Ptolemy* in 10 Books, but his Work is loſt. After theſe came out *Alhazen* the *Arabian*'s *Optics*, (who wrote about the Year 1100) a voluminous, tedious Piece: then *Vitellio*'s about the Year 1270; and *Peccam*'s, an Arch-Biſhop of *Canterbury*, about the Year 1279; alſo *Roger Bacon*, of *Oxford*, began to write of Optics about the ſame time. Amongthe moreModern, you have *Agulonius* and *Scheiner* the Jeſuit; *Taquet*, *Traber*, *Barrow*, *Zahan*, *Kircher*, *Newton*, and not long ago Dr. *Smith*, and Mr. *Martin*.

Optic Place *of a Star or Planet*, is that Point or Part of its Orbit, which is determined by our Sight, when the Star is there; and this is either true, when the Obſerver's Eye is ſuppoſed to be at the Centre of the Earth or Planet he inhabits; or apparent, when his Eye is at the Circumference of the Earth.

Orb, is only a hollow Sphere.

Orbis Magnus, is the Orbit of the Earth in its Annual Revolution round the Sun.

All the Ancients, and the Aſtronomers before the great *Kepler* ſuppoſed this Orbit to be a perfect Circle; but he proves it to be an Ellipſis; the remoteſt End of whoſe longer or tranſverſe Diameter is eight Signs, and eight Degrees diſtant from the firſt Star in *Aries*, and having the Sun in one of its Focal Points.

Orbit *of any Planet*, is the Curve that it deſcribes, about the Sun.

The Orbits of all the Planets are Ellipſes, having the Sun in their con-

common Focus: But the Elliptic Orbit of the Earth, by the Action of the Moon, is sensibly disfigur'd; as also the Orbit of *Saturn*, by the Action of *Jupiter*, when they are in Conjunction.

ORDER, in Architecture, is a particular Arrangement of Projectures; or 'tis a certain Rule for the Proportions of Columns, and for the Figures which some of the Parts ought to have on account of the Proportions that are given them. There are six, *viz.* the *Tuscan Order*, *Doric Order*, *Ionic Order*, *Corinthian Order*, *Composite Order*, and the *Attic Order*.

ORDER *of Curve Lines*. See *Geometric Lines*.

1. The chief Properties of the Conic Sections are every where treated of by Geometers; and of the same Nature are the Properties of the Curves of the second Gender, and of the rest; as from the following Enumeration of their principal Properties will appear.

2. For, if any Right and Parallel Lines be drawn and terminated on both Sides by one and the same Conic Section; a Right Line bissecting any two of them, shall bissect all the rest; and therefore, such a Line is called the *Diameter of the Figure*; and all the right Lines so bissected, are called *Ordinate Applicates to that Diameter*; and the Point of Concourse to all the Diameters, is called the *Centre of the Figure*; as the Intersection of the Curve, and of the Diameter, is called the *Vertex*, and that Diameter the Axis, to which the Ordinates are normally applied: And so in Curves of the second Gender; if any two right and parallel Lines are drawn meeting the Curve in three Points, a right Line which shall cut those Parallels, so that the Sum of two Parts terminated at the Curve on one Side of the intersecting Line shall be equal to the third Part terminated at the Curve on the other Side: This Line shall cut, after the same manner, all others parallel to these, and meeting the Curve in three Points; that is, shall so cut them, that the Sum of the two Parts on one Side of it, shall be equal to the third Part on the other.

And therefore, these three Parts, one of which is thus every where equal to the Sum of the other two, may be called *Ordinate Applicates* also: And the intersecting Line, to which the Ordinates are applied, may be called the Diameter; the Intersection of the Diameter and the Curve may be called the *Vertex*; and the Point of Concourse of any two Diameters, the *Centre*.

And if the Diameter be Normal to the Ordinates, it may be called the *Axis*; and that Point where all the Diameters terminate, the general Centre.

Asymptotes and their Properties.

3. The Hyperbola of the first Gender has two Asymptotes; that of the second, three; that of the third, four; and it can have no more, and so of the rest. And as the Parts of any right Line lying between the conical Hyperbola, and its two Asymptotes are every where equal; so in the Hyperbola's of the second Gender, if any right Line be drawn, cutting both the Curve and its three Asymptotes, in three Points; the Sum of the two Parts of that Right Line being drawn the same way from any two Asymptotes to two Points of the Curve, will be equal to the third Part drawn a contrary Way from the third Asymptote, to a third Point of the Curve.

Latera Transversa & Recta.

4. And as in Non-Parabolic Conic Sections, the Square of the *Ordinate Applicate*, that is, the Rectangle

angle under the Ordinates, drawn at contrary Sides of the Diameter, is to the Rectangle of the Parts of the Diameter, which are terminated at the Vertexes of the Ellipsis or Hyperbola, as a certain given Line, which is called the *Latus Rectum*, is to that Part of the Diameter that lies between the Vertexes, and is called the *Latus Transversum:* So in Non-Parabolic Curves of the Second Gender, a Parallelepipedon, under the three *Ordinate Applicates*, is to a Parallelopipedon under the Parts of a Diameter terminated at the *Ordinates*, and the three Vertexes of the Figure in a certain given *Ratio:* If you take three right Lines to the three Parts of a Diameter situated between the Vertexes of the Figure, one answering to another; then these three right Lines may be called the *Latera Recta* of the Figure, and the Parts of the Diameter between the Vertices, the *Latera Transversa*. And as in the Conic Parabola, having to one and the same Diameter but one only Vertex, the Rectangle under the Ordinates is equal to that under the Part of the Diameter cut off between the Ordinates and the Vertex, and a certain Line called the *Latus Rectum:* So in the Curves of the Second Gender, which have but two Vertexes to the same Diameter, the Parallelopipedon under the three Ordinates, is equal to the Parallelopipedon under the two Parts of the Diameter cut off between the Ordinates and those two Vertexes, and a given Right Line; which therefore may be called the *Latus Rectum*.

The Ratio *of the Rectangles under the Segments of Parallels.*

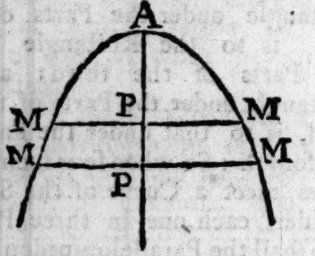
Lastly, As in the Conic Sections, when two Parallels, terminated on each Side at the Curve, are cut by two other Parallels terminated on each Side by the Curve; the first being cut by the third, and the second by the fourth; as here the Rectangle under the Parts of the first, is to the Rectangle under the Parts of the third; as the Rectangle under the Parts of the second, is to that under the Parts of the fourth: So when four such right Lines meet a Curve of the Second Gender, each one in three Points, then shall the Parallelopipedon under the Parts of the first right Line be to that under the Parts of the third as the Parallelopipedon under the Parts of the second Line is to that under the Parts of the fourth.

Hyperbolic and Parabolic Legs.

All the Legs of Curves of the second and higher Genders, as well as of the first, infinitely drawn out, will be of the Hyperbolic or Parabolic Gender; and I call that an *Hyperbolic Leg*, which infinitely approaches to some Asymptote; and that a Parabolic one, which hath no Asymptote. And these Legs are best known from the Tangents: For, if the Point of Contact be at an infinite Distance, the Tangent of an Hyperbolic Leg will coincide with the Asymptote; and the Tangent of a parabolic Leg will recede *in infinitum*, will vanish, and no where be found. Wherefore, the Asymptote of any Leg is found, by seeking the Tangent to that Leg at a Point infinitely distant: And the Course, Place, or Way of an infinite Leg, is found by seeking the Position of any right Line, which is parallel to the Tangent where the Point of Contact goes off *in infinitum:* For this right Line is directed towards the same way with the infinite Leg.

ORDINATES, or ORDINATE APPLICATES, are parallel Lines MM,

MM, terminating in a Curve, and bissected by a Diameter, as AP.



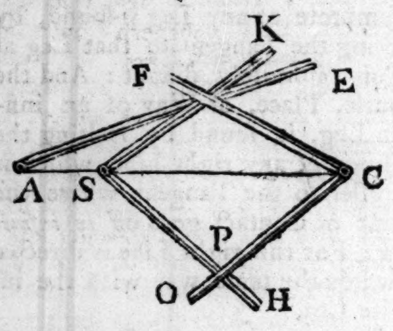
The half of which, as MP, is properly the *Semi-Ordinate*, but it is usually called the *Ordinate*.

ORDNANCE, are all sorts of great Guns used in War.

ORDONNANCE, signifies the same thing in Architecture that it does in Painting; to wit, the Composition of a Building, and the Disposition of all its Parts; it being this that determines the Bigness of the several Members, whereof a Building is composed.

ORGANICAL DESCRIPTION *of Curves*, is the Description of them upon a Plane, by means of Instruments.

1. If the given Angles FCO, and KSH move about two Points S and C given in any Plane, and the Concurrence of the Legs CF, SK, be moved along the Right Line AE given in Position in that Plane; then will the Concurrence

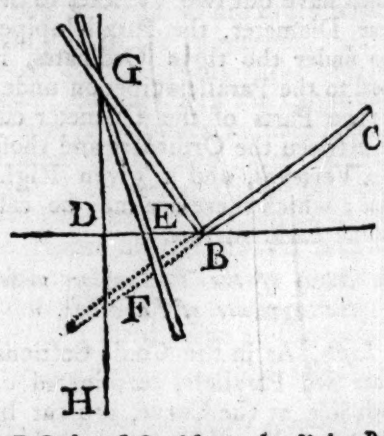


P, if the other Legs CO, SH, describe a Curve of the first kind, that is, a Conic Section: And to find which of the Conic Sections will be describ'd according to the various Magnitude of the given Angles FCO, and KSH, and Position of the Line AE, describe a Segment of a Circle on the given Line CS; containing an Angle equal to the Complement of the given Angles FCO, and KSH to four Right Angles: If the given Right Line AE meets that Circle twice, the Curve will be an Hyperbola: If it touches it, a Parabola: And if the Right Line AE falls quite beside the Circle, the Curve describ'd will be an Ellipsis.

2. While the Right Line AE remains, and the Sum of the given Angles FCO, and KSH, the Species of the Curve will be the same; and in no case will a Circle be describ'd, but when the Right Line AE goes out to Infinity.

3. If the given Angles above are mutually the Supplements of each other to two Right ones, and the Line AE meets CS continu'd out; there will be an Hyperbola describ'd: If AE be parallel to CS, a Parabola will be describ'd.

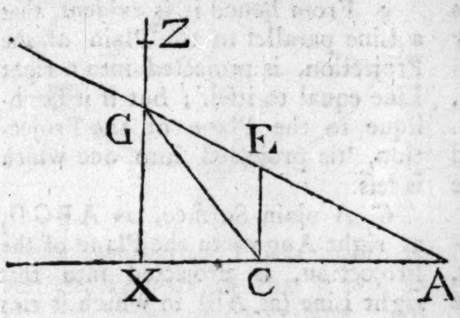
4. If the infinite Right Lines GH, DB cut one another at Right Angles, and the Angle B of a Square



ABC be fasten'd to the Point B in the Right Line DB, so as the Square may

may be moveable about it; and if FG be a Ruler moveable about the Point E in the Right Line DB, then if the Interſection G of the Ruler and one Side BB of the Square be carried along the Right Line HG, the Interſection F of that Ruler, and the other Side CB (continued out upon occaſion) will deſcribe one of the Conic Sections; which will be an Ellipſis, when the Point E is taken between D and B; an Hyperbola, when D is between E and B; and a Parabola, when E is at an infinite Diſtance, that is, when the Ruler always moves parallel to DB.

5. If ECA be a Right-angled Triangle, and the Sides AC, AE



be continued out, and if any Point X be taken in AC, and the Perpendicular XG be drawn; then if from the Point G be drawn the Right Line CG, and XZ be made equal to CG, the Point Z will be in a Conic Section, which will be an Ellipſis, when AC is greater than CE; an Hyperbola, when AC is leſs; and a Parabola, when AC is equal to CE.

Orgues, in Fortification, are many Harque-Buſſes. linked together, or divers Muſket-Barrels laid in a Row, within one wooden Stock, ſo that they may be diſcharged either all at once, or ſeparately. They are made uſe of to defend Breaches, and other Poſts that are attack'd.

This Term is alſo appropriated to certain long, and thick Pieces of Timber, armed with Iron Plates at the Ends, and ſeparated one from another. They are hung with Cords over the Gates of a Town or Fortreſs, and in caſe of a Surprize, let fall perpendicularly; by which means the Paſſage is ſtopped, ſo that the Enemy cannot eaſily remove or hoiſt up all the wooden Bars with a Leaver, or any other Machine ſet under them: On which account, theſe Orgues are to be preferred before Herſes or Portcullices, becauſe the Pieces whereof the latter conſiſt are joined together; ſo that when any Part is hung or heaved up, the whole Machine is likewiſe removed. Theſe Orgues therefore are much better than Portcullices.

Oriental, in Aſtronomy: A Planet is ſaid to be Oriental, when it riſes in the Morning before the Sun.

Orillon, in Fortification, is a ſmall Rounding of Earth lined with a Wall, which is raiſed on the Shoulder of thoſe Baſtions that have Caſemates to cover the Cannon in the retired Flank, and to prevent their being diſmounted by the Enemy.

There are alſo other ſorts of Orillons, properly called *Shoulderings*, which are almoſt of a ſquare Figure; they are called *Epaulments*.

Orion, a Southern Conſtellation, conſiſting of 39 Stars.

Orle, a Term in Architecture; the ſame with *Plinth*, which ſee.

Ornament, in Architecture, is any Piece of carved Work, ſerving as a Decoration in Architecture: But the Word in *Vitruvius* and *Vignola*, is uſed to ſignify the *Entablement*.

Orteil, a Term in Fortification; the ſame with *Berme*, which ſee.

Orthodromiques, is the Art of Sailing in the Arches of some great Circle: For the Arch of every great Circle is *Orthodromia*, or the shortest Distance between any two Points on the Surface of the Globe.

Orthography, in Mathematics, is the true Delineation of the fore-right Plane of any Object.

1. In Architecture 'tis taken for the Model, Platform and Delineation of the Front of a House that is to be built and contrived according to the Rules of Geometry; according to which Pattern, the whole Fabric is erected and finished.

2. In Perspective, the Orthography of any Body or Building is the fore-right Side of any Plane; that is, the Side or Plane that lies parallel to a straight Line, that may be imagined to pass thro' the outward Convex-Points of the Eyes, continued to a convenient Length. The word Schenography is used by *Lamy*, and others in the same sense.

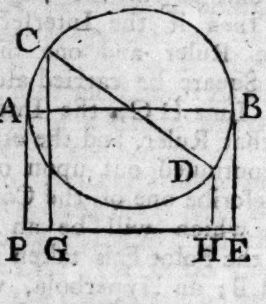
3. In Fortification, it is the Profile or Representation of a Fortress, made after such a manner, that the Length, Breadth, and Height of its several Parts may be discovered.

Orthographical Projection *of the Sphere*, is the drawing the Superficies of the Sphere on a Plane which cutteth it in the middle, the Eye being placed at an infinite Distance vertically to one of the Hemispheres.

1. The Rays by which the Eye, at an infinite distance, perceives any Object, are parallel.

2. A Right Line perpendicular to the Plane of the Projection, is projected into a Point, where that right Line cuts the Plane of the Projection.

3. A right Line, as AB, or CD, not perpendicular, but either parallel or oblique to the Plane of the Projection, is projected into a right Line, as EF, or GH; and is always comprehended between the

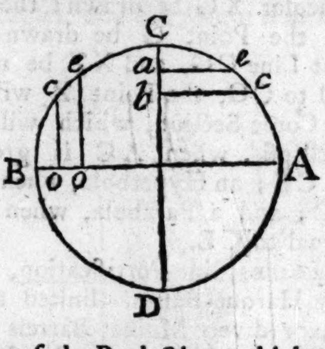


extreme Perpendiculars AP, and BE.

4. The Projection of the Right Line AB, is the greatest when AB is parallel to the Plane of the Projection.

5. From hence it is evident, that a Line parallel to the Plain of the Projection, is projected into a right Line equal to itself; but if it be oblique to the Plane of the Projection, 'tis projected into one which is less.

6. A plain Surface, as ABCD, at right Angles to the Plane of the Projection, is projected into that right Line (as AB) in which it cuts the Plane of the Projection. Hence it is evident, that the Circle BCAD standing at right Angles to the



Plane of the Projection, which passes thro' its Centre, is projected into that Diameter AB, in which it cuts the Plane of the Projection.

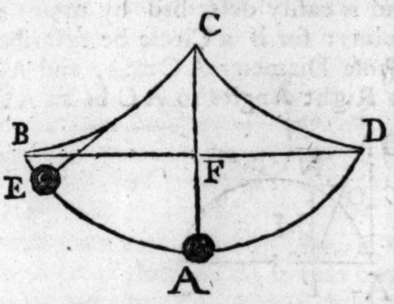
7. It is likewise evident, that any Arch as *cc* is projected into *oo*, equal

equal to Ca, Cb, which is the right Sine of that Arch; and the complemental Arch cA is projected into oA, the versed Sine of the same Arch CC.

8. A Circle parallel to the Plane of the Projection, is projected into a Circle equal to itself; and a Circle oblique to the Plane of the Projection, is projected into an Ellipsis.

OSCILLATION, is the reciprocal Ascent and Descent of a Pendulum.

1. If a single Pendulum be suspended between two Semi-Cycloids BC, CD, that have the Diameter CF



of the generating Circle equal to half the Length of the String, so that the String, as it oscillates, folds about them; all the Oscillations, however unequal, will be Isochronal in a non-resisting Medium.

2. The Time of an whole Oscillation, thro' any Arch of a Cycloid, is to the Time of the perpendicular Descent thro' the Diameter of the generating Circle, as the Periphery of the Circle to the Diameter.

3. If two Pendulums describe similar Arches of Circles, the Times of the Oscillations are in the subduplicate Ratio of their Lengths.

4. The Number of Isochronal Oscillations made in the same time by two Pendulums, are reciprocally as the times wherein each of the Oscillations are made. The Times of the Oscillations in different Cycloids, are in the subduplicate Ratio of the Length of the Pendulums.

5. The Length of a Pendulum that will perform its Oscillations in a Second, is 39.125 Inches, or three Feet 3.125.

6. The shorter the Oscillations in the Arch of a Circle are, the truer will the Pendulum measure Time, or the more Isochronal will the Oscillations be.

OSTENSIVE DEMONSTRATIONS, are such as plainly and directly demonstrate the Truth of any Proposition; in which they are distinguished from Apogogical ones, or *Deductiones ad absurdum, sive ad impossibile*, which prove the Truth proposed, by demonstrating the Absurdity or Impossibility of asserting the contrary.

OSTENSIVE DEMONSTRATIONS, are of two sorts; some of which barely (but directly) prove the Thing to be, which they call ὅτι; and others demonstrate the Thing from its Cause, Nature, or essential Properties, and these are called in the Schools διότι.

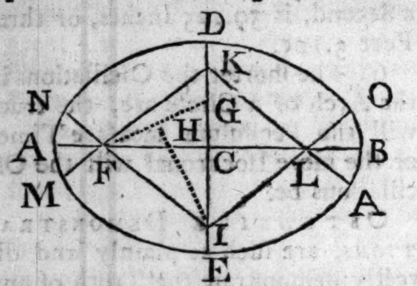
OTACOUSTICS, are Instruments which help or improve the Sense of Hearing.

OVAL, in Architecture, the same with Echinus. Some write it Ova, because of its Figure, being like an Egg; it is placed in the Mouldings of the Cornices for Ornament; and in a Pillar it is placed next to the Abacus.

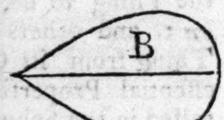
OVAL FIGURE, in Geometry, is a Figure bounded by a Curve Line returning into itself.

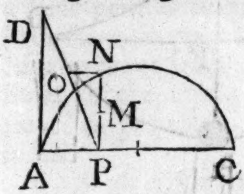
A Figure bounded by circular Arches, so meeting as to coincide at the Points of meeting with the Tangents to the Arches, and as to appearance not differing from an Ellipsis, is by Artificers call'd an Oval, and may be thus described, to any given Length and Breadth. Let the given Length AB and Breadth DE cut one another at right Angles, and in half at the Point C,

assume the right Lines AF, LB equal; but less than $\frac{1}{2}$ the Breadth CD, and about the Centres F, L, with the Distances AF, LB, describe two small Arches MAN, ABO; take DG equal to AF, join FG, which divide into two equal Parts at H, and from H draw the Right Line HI perpendicular to FG, meeting the Diameter CE in I. This done, about the Centres KI, with the Distance IN, describe two Arches NDO, MEA, and the Oval required will be described.



Altho' it is usual to call only a Curve, resembling an Ellipsis, an Oval; yet there are really in nature an infinite Variety of Geometrical Ovals, of very different and pleasant Figures, expressed by Equations of all Dimensions about the second, and more especially those of the even Dimensions; as the Equation $aayy = -x^4 + ax^3$ represents the Oval B, in shape of the Section of a Pear thro' the middle, and is easily described by means of Points; for if a Circle be described whose Diameter $AC = a$, and AD at Right Angles to AC be $= AC$, and any Point P be taken in AC, and PM be drawn parallel to AD, and DP be drawn, and then NO; and if PM be taken equal to NO, the Point M will be one Point of the Oval sought.





In like manner the Equation $y^4 - py^2 = -ax^4 + bx^3 + cx^2 + dx + e$, expresses several very pretty Ovals, amongst which the following twelve are most observable; for if the Equation $ax^4 = bx^3 + cx^2 + dx + e$ has four real unequal Roots; the three Species, as appears in *Fig.* 1, 2, 3, will be expressed by the given Equation. When the two lesser Roots are equal, the three Species as appears in *Fig.* 4, 5, 6,

Fig. 1.

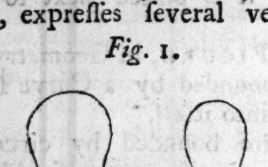


Fig. 2.

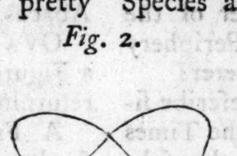


Fig. 3.

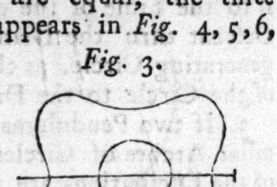


Fig. 4.

Fig. 5.

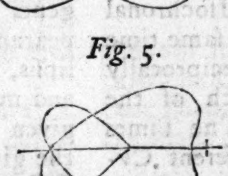


Fig. 6.

will

will be expressed. When the two lesser Roots become imaginary; the three Species, as appear in *Fig.* 7, 8, 9, will be expressed. And when the two middle Roots are equal, the Species will be as appears in *Fig.* 10. when two Roots are equal, and two more so, the Species will be as appears in *Fig.* 11. and when the two middle Roots become imaginary, the Species will be as appears in *Fig.* 12.

Fig. 7.

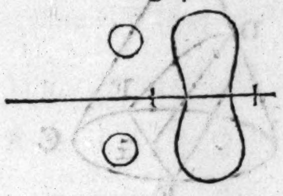


Fig. 8.

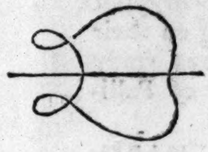


Fig. 9.

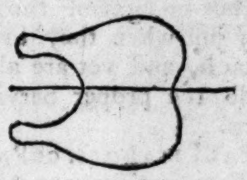


Fig. 10.

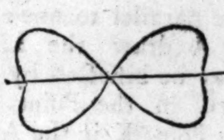


Fig. 11.

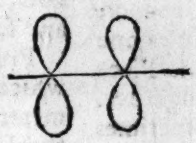
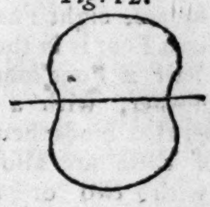


Fig. 12.



OUTWARD *Flanking Angle*, or *the Angle of the Tenaille*, is that comprehended by the two Flanking-Lines of Defence.

OUT-WORKS, in Fortification, are all sorts of Works, which are raised without the Inclosure of a Place, and serve for its better Defence, and to cover it from the Enemy, in the Plain without; as Ravelins, Half-Moons, Horn-Works, Crown-Works, Counter-Guards, Tenailles, &c.

1. It is a general Rule in all Out-Works, that if there be several of them, one before another, to cover one and the self-same Tenaille of a Place, the nearer ones must gradually, and one after another, command those which are farthest advanced out into the Campagne; that is, must have higher Ramparts, that so they may overlook and fire upon the Besiegers, when they are Masters of the more Outward-Works.

2. The Gorges also of all Out-Works must always be plain, and without Parapets; lest, when taken, they should serve to secure the Besiegers against the Fire of the retiring Besieged; wherefore the Gorges of Out-Works are only pallisadoed, to prevent a Surprize.

OVOLO, in Architecture; see *Quarter-round.*

OXYGONE, the same with an acute-angled Triangle, and in general

OXYGONIAL, is acute-angular.

P.

PALLET, is a Term belonging to the *Ballance* of a Watch, or Movement.

PALLIFICATION, in Architecture, is the piling the Ground-Work, or strengthening it with Piles or Timber driven into the Ground, when they build upon a moist or marshy Soil.

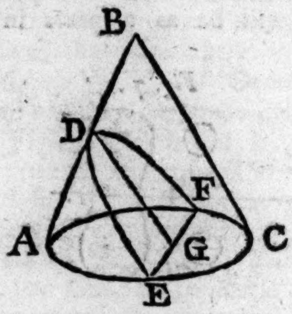
Pallisades Turning, are an Invention of Mr. *Coehorne*'s: For, in order to preserve the Palisadoes of the Parapet from the Besiegers Shot, he orders them so, that many of them stand in the Length of a Rod, or in about ten Foot, and turn up and down like a Trap; so that they are not in sight of the Enemy, but only just when they bring on their Attack, and yet are always ready to do the proper Service of Pallisades.

Pallisadoes, or Pallisades, in Fortification, are strong wooden sharp-pointed Stakes, six or seven Inches square, eight Foot long, of which three Foot is in the Ground; set up half a Foot sometimes one above another, with a cross Piece of Timber that binds them together. Some of these are also sometimes arm'd with two or three Iron Spikes.

1. These Pallisadoes are usually fixed in the void Spaces without the Glacis near the Bastions and Curtains; and in Avenues of all such Posts as are liable to be surprized by the Enemy, or carried by Assault. Sometimes they are driven downright in the Ground, and sometimes stand at an acute Angle towards the Enemy, that if they should throw Cords about them to pull them up, they may slip off again.

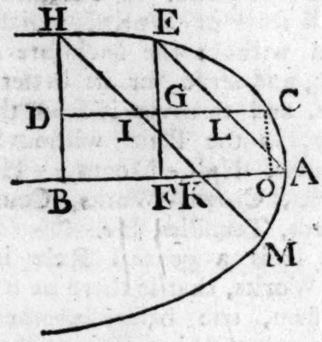
2. Pallisadoes are always planted on the Berme of Bastions, and at the Gorges of Half-Moons, and other Out-Works: They also pallisade usually the Bottom of the Ditch; and to be sure, the Parapet of the Cover'd-Way: And tho' sometimes they have placed these Pallisadoes three Foot, from the said Parapet outwards towards the Campagne; yet of late they have been planted in the very middle of the Cover'd-way. All Pallisadoes should stand so close, as to admit between them only the Muzzle of a Musket, or Pike.

Parabola, is a Curve, as EDF, made by cutting a Cone by a Plane DG, parallel to one of its Sides, as BC.



1. All Diameters DC of a Parabola, are parallel to the Axis BA, and so are parallel to one another.

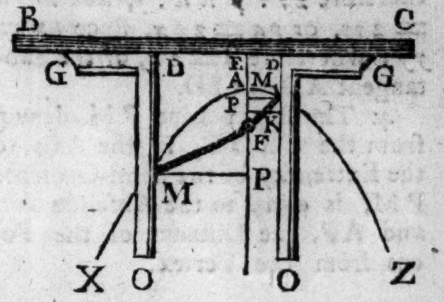
From A draw the Line AE, which may be bissected by the Diameter DC in the Point L; and thro' any Point K in the Axis draw HKM. Also from the Points H, E, C, draw the Semi-Ordinates HB, EF, CO, to the Axis, which will be all perpendicular to the same; then call the given Line CO,



or GF, or DB, a; and BH, y; and the Parameter to the Axis p. Now $OA = \frac{aa}{p}$, $FA = \frac{4aa}{p}$, and $GL = \frac{2aa}{p}$, (because the Triangles EFA, EGL, being similar, and the Side EA bissected in L, the Side EF shall be bissected in G, and

and GL shall be $= \frac{1}{2}$ FA) and LC $= \frac{aa}{p} \left(= \text{OA}\right)$ and $\overline{\text{EL}}^2 = aa + \frac{4a^4}{pp}$. And because the Triangles EFA, HBK, are similar, therefore EF $(2a)$: FA $\left(\frac{4aa}{p}\right)$ :: HB (y) : BK $= \frac{2ay}{p}$. But BA — BK + OA = IC $= \frac{yy - 2ay + aa}{p}$, since IL is = KA and OA = LC. Therefore LC $\left(\frac{aa}{p}\right)$: IC $\left(\frac{yy-2ay+aa}{p}\right)$ :: $\overline{\text{EG}}^2$: (aa) $\overline{\text{HD}}^2$ $(yy - 2ay + aa)$ :: $\overline{\text{EL}}^2$: $\overline{\text{HI}}^2$, because the Triangles DHI, GEL, are similar, and consequently EC : IC :: $\overline{\text{EL}}^2$: $\overline{\text{LA}}^2$. And drawing a Perpendicular from the Point M to DC, and reasoning after the same manner, you will have CL : CD :: $\overline{\text{LA}}^2$ $(= \overline{\text{LE}}^2)$: $\overline{\text{IM}}^2$. Whence IM is = IH; and because the Point K is taken at pleasure in the Axis; therefore all Right Lines drawn parallel to EA, shall be bissected by the Line DC, and so the same shall be a Diameter according to the Definition, and the Lines EA and HKM shall be Ordinates to it.

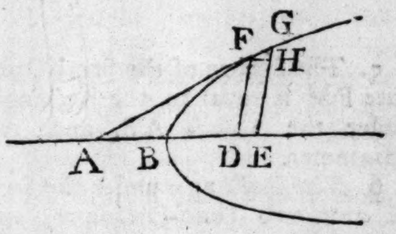
2. If the Rule BC be placed upon a Plane, together with the Square GDO, in such manner, that DG, one of its Sides, lies along the Edge of that Rule; and if you take the Thread FMO equal in Length to DO, the other Side of the Square, and fix one End thereof to O the Extremity of the Side DO, and the other in any Point F, taken in the Plane on the same side of the Rule as the Square: This being done, if you slide DG, the Side of the Square along the Rule BC, and at the same time keep the Thread continually tight by means of the Pin M, with its Part MO close to the side of the



Square DO: The Curve AMX, which the Pin describes by this Motion, is one Part of a Parabola.

And if the Square be turn'd about, and moves on the other side of the fixed Point F, the other Part AMZ of the same Parabola may be described after the like manner; so that the Line XAZ will be one and the same Curve.

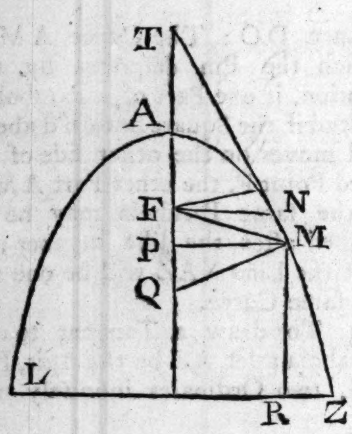
3. To draw a Tangent to the Parabola; let AE be the Axis, DF, EG, two Ordinates infinitely near



to each other, and FH parallel to AE: Let p be the Parameter, AF the Tangent (to be drawn) $= a$, BD $= x$, DE $= s$, and DF $= y$. Then $px = yy$, and $px + ps = yy + 2\,\text{GH} \times y + \overline{\text{GH}}^2$. But since GH is infinitely small $\overline{\text{GH}}^2$ is infinitely less than $2\,\text{GH} \times y$, and so may be rejected; so that $px + ps$ =

$= yy + 2\,GH \times y$; and if from this Equation be taken $px = yy$, we ſhall have $ps = 2\,GH \times y$; and ſo $s : GH :: 2y : p$. But becauſe of the ſimilar Triangles ADF, FHG, it will be $s : GH :: a : y$; therefore $2y : p :: a : y$, and ſo $pa = 2yy$, or $pa = 2px$, ſince $px = yy$; wherefore $a = 2x$, or the Subtangent $AD = 2\,BD$.

4. The Right Line FM drawn from the Focus F, in the Axis to the Extremity of the Semi-Ordinate PM, is equal to the Abſciſſæ AP and AF, the Diſtance of the Focus from the Vertex.



5. The Square of the Semi-Ordinate PM is equal to the Rectangle under the Abſciſs AP, and the Parameter.

6. The Rectangle under the Sum of any two Semi-Ordinates, and their Difference, is equal to a Rectangle under the Parameter, and the Difference of the Abſciſſes.

In the Parabola, the Sub-Tangent PT is twice the Abſciſs AP, and the Sub-Normal $PQ = \frac{1}{2}$ the Parameter, and ſo is a conſtant Quantity.

7. The Focus of the Parabola is at ſuch a diſtance from the Vertex, that the Semi-Ordinate $FN = \frac{1}{2}$ the Parameter.

8. The Rectangle under LR and RZ is equal to RM into the Parameter; and ſo is a conſtant Quantity.

9. If a be the Parameter, and $y = PM$, then $y + \frac{2y^3}{3a^2} - \frac{2y^5}{5a^4} - \frac{4y^7}{7a^6} - \frac{10y^9}{9a^8}$, &c. will be the Length of the Curve AM of the Parabola.

The Length of the Curve of the Parabola may be obtained by means of the Quadrature of the Hyperbolic Space, which was firſt taken notice of by Mr. *Huygens*, in the Year 1657; for if there be two oppoſite equilateral Hyperbola's, whoſe tranſverſe Axis is equal to the Parameter of the Axis of the Parabola; then the Space contain'd under that Tranſverſe Axis, the Curves of the oppoſite Hyperbola's, and a Right Line drawn parallel to that Tranſverſe Axis will be equal to the Part of the Curve of the Parabola, whoſe Semi-Ordinate is equal to the Diſtance of the ſaid Parallel from the Tranſverſe Axis of the Hyperbola drawn into $\frac{1}{2}$ the *Latus rectum* of the Axis of the Parabola. Hence the Length of the Curve of the Parabola may be had by means of the Logarithms, and that after the following manner. Let x be the Abſciſs and y the Semi-Ordinate of the Parabola; ſay, as the conſtant Number 0,434294 is to the Logarithm of the Ratio of $\sqrt{xx + \frac{yy}{4}} + x$ to y, ſo is $\frac{1}{4}$ of the Parameter of the Axis, to a fourth Number, which added to $\sqrt{xx + \frac{yy}{4}}$ will be the Length of $\frac{1}{2}$ the Curve of the Parabola, whoſe Abſciſs is x, and Ordinate $2y$.

Parabolic Conoid, is a Solid generated by the Rotation of a Parabola about its Axis.

This

This Solid is $\frac{1}{2}$ a Cylinder of the same Base, and Altitude; for the Circular Planes parallel to the Base, are as the Numbers in Arithmetical Progression, from the Nature of the Parabola; that is, are as the Ordinates of a Triangle.

A Circle equal to the Curve Superficies of a Parabolic Conoid, is thus most elegantly found by Mr. *Huygens*, in his *Horolog*. Draw the Tangent (*Fig.* 1.) MT, and divide the Ordinate MP in O, so that MO be to OP, as MT to MP;

Fig. 1.

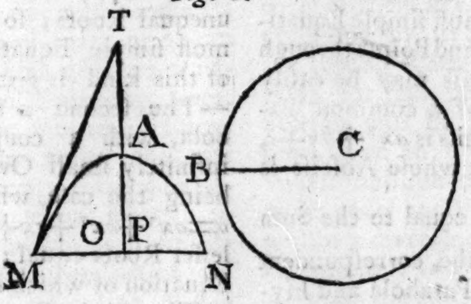
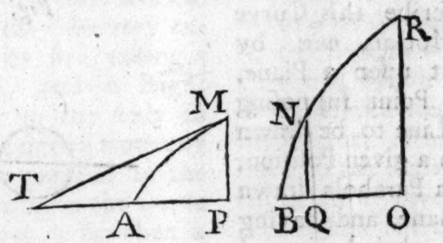
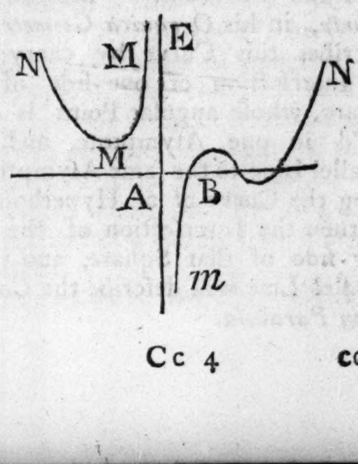


Fig. 2.



then if between TM + OP and $\frac{1}{3}$ MN, you find a mean Proportional BC; the Circle described with BC for its Radius, will be equal to the Curve Surface of the Parabolic Conoid generated by the Rotation of the Parabola MAN about its Axis AP. Mr. *Huygens* does not demonstrate this; but it is easily enough done from hence: Let (*Fig*. 2.) BNR be a Parabola described to any Axis BQO, whose principal Vertex is B, with a *Latus rectum* to the Axis, equal to four times the *Latus rectum*, suppose L, of the Axis AP of the Parabola AM, and let BQ be $= \frac{1}{4}$ L, and QO = AP, and draw the Ordinates QN, OR. Then it will be as the Diameter of a Circle is to its Circumference, so is the Parabolic Trapezium QNRO to the Curve Superficies of the Parabolic Conoid generated from the Parabola AMP.

PARABOLA *Cartesian*, is a Curve of the second Order expressed by the Equation $xy = ax^3 + bx^2 + cx + d$, containing four infinite Legs, *viz.* two Hyperbolic ones, MM, B*m*, (AE being the Asymptote) tending



contrary ways, and two Parabolic Legs DN, MN joining them, being the 66th Species of Lines of the third Order, according to Sir *Isaac Newton*, call'd by him a *Trident*, and is made use of by *Descartes*, in the third Book of his *Geometry*, for finding the Roots of Equations of six Dimensions by its Intersections with a Circle. Its most simple Equation is $xy = x^3 + a^3$, and Points through which it is to pass may be easily found by means of a common Parabola whose Abscis is $ax^2 + bx + c$, and an Hyperbola whose Abscis is $\frac{d}{x}$; for y will be equal to the Sum or Difference of the correspondent Ordinates of this Parabola and Hyperbola.

Descartes, in the aforesaid Book, shews how to describe this Curve by a continued Motion, *viz.* by taking a fixed Point upon a Plane, and without that Point supposing an infinite Right Line to be drawn upon that Plane in a given Position, and then taking a Parabola drawn upon a separate Plane, and having assumed a Point in the Axis, and fasten'd a Ruler to the same, as also to the Point assumed upon the Plane, he moves the Plane of the Parabola along, so as its Axis always coincides with the Line drawn upon the Plane in a given Position, and then the Intersections of the Curve of the Parabola and the long Ruler will describe upon the Plane the *Cartesian Parabola*.— Mr. *Mac-Laurin*, in his *Organica Geometria*, describes this Curve by carrying the Intersection of one side of a Square, whose angular Point is fasten'd in one Asymptote, and a parallel Line to the same Asymptote along the Curve of an Hyperbola; for then the Intersection of the other side of that Square, and the Parallel Line will describe the *Cartesian Parabola*.

Parabola *Diverging*, is a Name given by Sir *Isaac Newton* to five different Lines of the third Order, expressed by the Equation $yy = ax^3 + bx^2 + cx + d$. The first (*Fig.* 1.) being a Bell-Form Parabola, with an Oval at its Head, which is the case when the Equation $o = ax^3 + bx^2 + cx + d$, has three real and unequal Roots; so that one of the most simple Equations of a Curve of this kind is $pyy = x^3 + ax^2 + aax$. —The second a Bell-Form Parabola, with a conjugate Point or infinitely small Oval at the Head, being the case when the Equation $o = ax^3 + bx^2 + cx + d$ has its two lesser Roots equal; the most simple Equation of which is $pyy = x^3 - axx$. —The third (*Fig.* 2.) a Parabola,

Fig. 1.

Fig. 2.

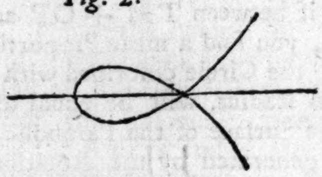
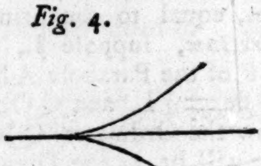


Fig. 3.

Fig. 4.



with

with two diverging Legs crossing one another like a Knot, which happens when the Equation $o=ax^3+bx^2+cx+d$ has its two greater Roots equal; the most simple Equation being $pyy=x^3+axx$.—The fourth (*Fig.* 3.) a pure Bell-form Parabola, being the case when $o=ax^3+bx^2+cx+d$ has two imaginary Roots, and its most simple Equation is $pyy=x^3+a^3$, or $pyy=x^3+aax$.—The fifth (*Fig.* 4.) a Parabola with two diverging Legs, forming at their meeting a Cuspe or double Point, being the case when the Equation $o=ax^3+bx^2+cx+d$ has three equal Roots; so that $pyy=x^3$ is the most simple Equation of this Curve, which indeed is the *Semi-cubical* or *Nelian* Parabola.

Points thro' which these five Parabolas must pass may be very expeditiously found by first taking a common Parabola, and a Right Line perpendicular to the Axis so situated, that a Line drawn from any Point in this Line parallel to the Axis, and terminating in the Curve shall be $=ax^2-bx+c$; for then a mean Proportional between this Line and any assumed Value of x will be the Length of an Ordinate of the five diverging Parabolas, corresponding to the assumed Value of x. All five of these Curves may be described too by a continued Motion, by means of a square Bevel and common Parabola; for if the Angle of a Bevel (containing $\frac{1}{2}$ a right Angle) be carried along the Curve of a common Parabola, one side thereof keeping parallel to the Axis of the Parabola; and if at the same time one Side of a Square passes through a given Point, not within the Parabola, and the Intersection of the other Side of the Bevel and of the Square passes along a Right Line drawn from the said Point perpendicular to the Axis, in such manner that the angular Point of the Square always coincides with the Side of the Bevel first mentioned; then will this Point of the Square trace out upon the Plane a part of a diverging Parabola.

If a Solid generated by the Rotation of a semi-cubical Parabola about its Axis be cut by a Plane, each of these five Parabolas will be exhibited by its Sections; for when the cutting Plane is oblique to the Axis, but falls below the Axis, the Section will be a diverging Parabola, with an Oval at its head.—When oblique to the Axis, but passes thro' the Vertex, the Section will be a diverging Parabola, having an infinitely small Oval at its head.—When the cutting Plane is oblique to the Axis, falls below it, and at the same time touches the Curve-Surface of the Solid, as well as cuts it, the Section will be a diverging Parabola, with a Nodus or Knot.—When the cutting Plane falls above the Vertex, either parallel or oblique to the Axis, the Section will be a pure diverging Parabola.—And when the cutting Plane passes thro' the Axis, the Section will be a semi-cubical Parabola.

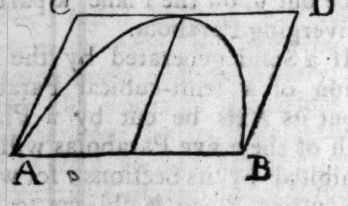
I might have been much more full and particular about these Curves, as I am in my Treatise of Curves that I have by me; but it would swell this Book too much.

Parabolic Pyramidoid, is a solid Figure, thus named by Dr. *Wallis*, from its *Genesis*, or *Formation*, which is thus:

Let all the Squares of the Ordinates of a Parabola be imagined to be so placed, that the Axis shall so pass thro' all their Centres at Right Angles; and the Aggregate of these Planes will form the *Parabolic Pyramidoid*, whose Solidity is gain'd by multiplying the Base by half the Altitude.

Parabolic Space, is the Area con-

contained between the Curve of the Parabola, and a whole Ordinate AB.



This is $\frac{2}{3}$ of the circumscribing Parallelogram ACDB, in the common Parabola.

The Quadrature of the Parabola was first found out by the great *Archimedes*; but his Demonstration, altho' very ingenious, is both long and tedious. It is more elegantly done by means of the Solidity of a square Pyramid, which is $\frac{1}{3}$ of a Parallelepipedon, having the same Base and Altitude; for every Ordinate to a Tangent to the Vertex of a Parabola, taken as an Abscis, will be as a correspondent square Section of the Pyramid, by a Plane parallel to the Base; and the Sum of all those Ordinates, as the Sum of all those Spaces, therefore, &c.

PARABOLIC SPINDLE, is a Solid made by the Rotation of a Semiparabola about one of its Ordinates, and is equal to $\frac{8}{15}$ of its circumscribing Cylinder.

PARABOLIC SPIRAL. See *Helicoid Parabola*.

PARABOLOIDES, or PARABOLIFORM CURVES, are Parabola's of the higher kind.

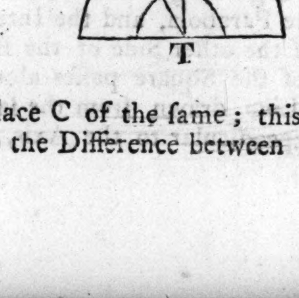
The Equation for all Curves of this kind being $a^{m-n}nx=y^m$, and the Proportion of the Area of any one to the Complement of it to the circumscribing Parallelogram will be as *m* to *n*.

PARACENTRIC MOTION *of Impetus*, is a Term in the New Astronomy, for so much as the revolving Planet approaches nearer to, or recedes farther from the Sun or Centre of Attraction. Thus if a Planet in A moves to B, then is SB—SA $=bB$, the Paracentric Motion of that Planet.

PARACENTRIC SOLLICITATION *of Gravity or Levity*, (which is all one with the *Vis Centripeta*,) is in Astronomy expressed by the Line AL drawn from the Point A, parallel to the Ray SB, (infinitely near SA,) until it intersects the Tangent BL.

PARALLACTICAL ANGLE, is the Difference of the Angles CEA, and BTA, under which the true and apparent Distances from the Zenith are seen.

PARALLAX, or PARALLAX *of Altitude*, is CB (or the Angle TSE, which may be taken for it) the Difference between the true Place B of the Planet S, and the apparent



Place C of the same; this is equal to the Difference between AB, the true

true Distance from the *Zenith* A, and the apparent Distance AC.

PARALLAX *of Ascension or Descension*, is an Arch of the Equinoctial, whereby the *Parallax of Altitude* augments the Ascension, and diminishes the Descension of a Planet.

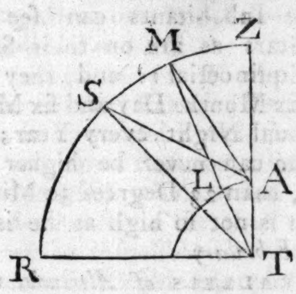
PARALLAX *of Declination*, is an Arch of a Circle of Declination, whereby the *Parallax of Altitude* augments or diminishes the Declination of a Planet.

PARALLAX *of Latitude*, is an Arch of a Circle of Latitude, whereby the *Parallax of Altitude* augments or diminishes the Latitude.

PARALLAX *of Longitude*, is an Arch of the Ecliptic, whereby the *Parallax of Altitude* augments or diminishes the Longitude.

1. The Parallax in the *Zenith*, is nothing, but in the *Horizon* the greatest.

2. The Sines of the *Parallactical Angles* AMT, AST, at the same or equal Distances SZ, from the *Zenith* are in the reciprocal Ratio of



the Distances TM, and TS, from the Centre of the Earth.

3. The Sines of the *Parallactical Angles* of the Stars M and S, equally distant from the Centre of the Earth T, are as the Sines of the apparent Distances ZM, and ZS, from the *Zenith*. The fixed Stars have no sensible Parallax.

4. The Horizontal Parallax is the same, whether a Star be in the true Horizon, or the apparent Horizon.

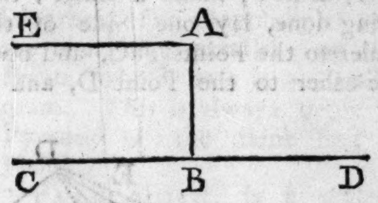
5. The Moon's greatest Horizontal Parallax, is 1°. 1'. 25''. and the least 54'. 5''.

6. The Horizontal Parallax of *Mars*, when greatest is about 25'', and that of the Sun is about 10''.

PARALLEL-LINES, in Geometry, are those which run always equi-distant from each other; so that if they were infinitely produced, they would neither go farther from, nor come nearer to each other; and their Distance is always measured by a Perpendicular, which, wherever it be taken, is of the same Length, or is always equal to itself.

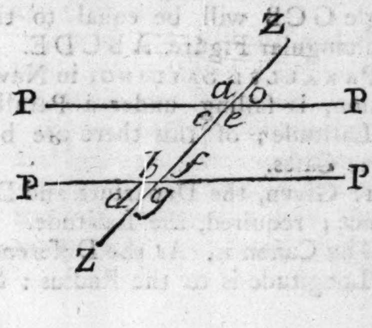
1. Sir *Isaac Newton*, in the 22d *Lemma* of the first Book of his *Principia*, defines Parallels to be such Lines that tend to a Point infinitely distant.

2. Or Parallel Lines may be defined thus: If A be a Point without a given indefinite Right Line CD; the shortest Line, as AB,



that can be drawn from A to it, is perpendicular; and the longest, as EA, is parallel to CD.

3. A Right Line ZZ falling on two parallel Lines PP and PP, makes the alternate Angles $o = f$,



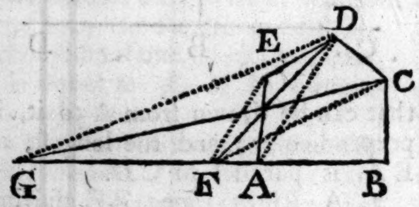
and

and $e=b$; also $o=d$, and $a=g$, and the two internal Angles $c+b$, or $e+f=$ two right ones.

Parallel-Planes, are those Planes which have all the Perpendiculars drawn betwixt them equal to each other; that is, when they are every where equally distant.

Parallel-Ruler, is an Instrument of Wood, Brass, Silver, &c. consisting of two Parallel-Rules that open and shut parallel to one another; and is of great use in all Parts of Mathematicks, where many Parallel-Lines are to be drawn; and is particularly useful in reducing of any multangular Figure to a Triangle.

As suppose the Multangular Figure A B C D E is to be reduced into the Triangle G C B, by means of the Parallel-Ruler; first continue out the Side A B, and laying one Side of the Instrument to the Points A, D, open the other to the Point E, and where it cuts the Line A G, as in F, make a Mark; this being done, lay one Side of the Ruler to the Points F, C, and open the other to the Point D, and it



will cut the Line B G in G; then draw the Line C G, and the Triangle G C B will be equal to the Multangular Figure A B C D E.

Parallel Sailing, in Navigation, is sailing under a Parallel of Latitude; of this there are but three Cases.

1. Given, the Departure and Distance; required, the Latitude.

The Canon is, As the Difference of Longitude is to the Radius: So is the Distance to the Co-sine of the Latitude.

2. Given, the Difference of Longitude between two Places under the same Parallel; required their Distance.

The Canon is, As the Radius is to the Difference of Longitude: So is the Co-sine of the Latitude to the Distance.

3. Having the Distance between two Places in the same Latitude; required, their Difference of Longitude.

The Canon is, As the Co-sine of the Latitude is to the Distance: So is the Radius to the Difference of Longitude.

Parallel Sphere, is where the Poles are in the *Zenith* and *Nadir*, and the *Equator* in the *Horizon*, which is the case of such (if any such there be) who live directly under the North or South Poles.

The Consequences of this Position are, that the Parallels of the Sun's Declination will also be Parallels of his Altitude.

The Inhabitants can see only such Stars as are on their Side of the Equinoctial; and they must have six Months Day and six Months continual Night every Year; and the Sun can never be higher with them, than 23 Degrees 30 Minutes, which is not so high as he is with us in *February*.

Parallels *of Altitude*, or *Almacanters*, are Circles parallel to the Horizon, imagined to pass thro' every Degree and Minute of the Meridian, between the Horizon and Zenith, having their Poles in the Zenith. And on the Globes these are described by the Divisions on the Quadrant of Altitude, in its Motion about the Body of the Globe, when 'tis screw'd to the Zenith of any Place.

Parallels *of Latitude on the Terrestrial Globes*, are the same with

Parallels

Parallels of Declination on the Celestial: But the *Parallels of Latitude on the Celestial Globes* are ſmall Circles parallel to the Ecliptic, imagined to paſs thro' every Degree and Minute of the Colures, and are repreſented there by the Diviſions of the Quadrant of Altitude, in its Motion round the Globe, when it is ſcrewed over the Poles of the Ecliptic.

PARALLELS *of Declination*, are Circles parallel to the Equinoctial, imagined to paſs thro' every Degree and Minute of the Meridians between the Equinoctial, and each Pole of the World.

PARALLEL RAYS, in Optics, are thoſe that keep an equal Diſtance from the viſible Object to the Eye, which is ſuppoſed to be infinitely remote from the Object.

PARALLEL CIRCLES, *on the Globes*; the ſame with the *Leſſer Circles*.

PARALLELS *alſo on the Terreſtrial Globe*, are Circles drawn thro' the middle of every Climate, dividing them into two halves, which are called *Parallels*.

PARALLELISM *of the Earth's Axis*, is the Earth's keeping its Axis in its annual Revolution round the Sun, in a Poſition always parallel to itſelf, which it doth nearly, but not exactly; for tho' the Difference be inſenſible in one Year, it becomes ſenſible enough in many Years.

PARALLELOGRAM, in Geometry, is a Right-lined Quadrilateral Figure, whoſe oppoſite Sides are parallel and equal.

1. The oppoſite Angles of all Parallelograms are equal to one another.

2. All Parallelograms that are between the ſame Parallel-Lines, and on the ſame Baſe, are equal.

3. All ſimilar Parallelograms are to one another in the duplicate Ratio of their homologous Sides.

4. The Area of any Parallelogram is had by multiplying one of its Sides by a Perpendicular let fall from one of the oppoſite Angles.

5. In any Parallelogram the Aggregate of the Squares of the Sides is equal to the Aggregate of the Squares of the Diagonals.

PARALLELOGRAM, is alſo an Inſtrument made of five Rulers of Braſs or Wood, with Sockets to ſlide or ſet to any proportion, uſed to enlarge or diminiſh any Map or Draught, either in Fortification, Building, or Surveying *&c.*

PARALLELOGRAM PROTRACTOR, is a Semi-Circle of Braſs with four Rulers, in form of a Parallelogram, made to move to any Angle: One of which Rulers is an Index, which ſhews on the Semi-Circle the Quantity of any inward or outward Angle.

PARALLELEPIPEDON, is a ſolid Figure contained under ſix Parallelograms, the Oppoſites of which are equal and parallel; or 'tis a Priſm, whoſe Baſe is a Parallelogram. This is always triple to a Pyramid of the ſame Baſe and Height.

PARALOGISM, is a pretended Demonſtration or Method of arguing, but which is in reality fallacious and falſe.

PARAMETER, by ſome, as *Mydorgius*, and others, called the *Latus Rectum* of a Parabola, is a third Proportional to the Abſciſſa and any Ordinate.

But in the Ellipſis and Hyperbola, it is a third Proportional to two conjugate Diameters.

PARAPET, in Fortification, is an Elevation of Earth and Stone upon the Rampart, behind which the Soldiers ſtand ſecure from the Enemy's great and ſmall Shot, and where

where the Canon is planted for the Defence of the Town or Fortreſs.

Every Parapet having its Embraſures and Merlons, is about ſix Foot high on the ſide of the Place, and from four to five in that towards the Country. So that this Difference of Height forms a kind of Glacis above, from whence the Muſqueteers mounting the Banquet of the Parapet, may eaſily fire into the Moats, or at leaſt upon the Counterſcarp. It ought alſo to be from eighteen to twenty Foot thick, if made of Earth; and from ſix to eight, if of Stone. The Earth is much better than Stone, becauſe Stone will fly to pieces when battered, and do miſchief.

This word Parapet is alſo given to any Line that covers Men from the Enemy's Fire: So there are Parapets of Barrels, of Gabions, of Bags filled with Earth, *&c.*

PARASTÆ, in Architecture, are the ſame with Pilaſters; the *Italians* call them *Membretti.*

PARHELII *and* PARHELIA *are ſuch* Phænomena, *as we call* Mock-Suns, being the Repreſentations of the Face or Figure of the true Sun by way of Reflexion in the Clouds.

PARTICLES, are the very ſmall Parts of which any natural Body is ſuppoſed to be compounded; and theſe are often called the conſtituent or component Particles of any natural Body.

PATE, in Fortification, is a kind of Platform like what they call an *Horſeſhoe*, not always regular, but generally oval, encompaſſed only with a Parapet, and having nothing to flank it; and is uſually erected in marſhy Grounds, to cover a Gate of a Town.

PATH *of the Vertex*, is a Term frequently uſed by Mr. *Flamſtead*, in his *Doctrine of the Sphere*, and ſignifies a Circle deſcribed by any Point of the Earth's Surface, as the Earth turns round its Axis. This Point is conſidered as vertical to the Earth's Centre, and is the ſame with what is called the *Vertex*, or the *Zenith* in the *Ptolemaic* Projection.

The Semi-Diameter of this Path of the Vertex is always equal to the Complement of the Latitude of the Point or Place that deſcribes it; that is, to that Place's Diſtance from the Pole of the World.

PAUSE or REST, in Muſic, is a Silence, or artificial Intermiſſion of the Voice or Sound, proportioned to a certain Meaſure of Time, by the Motion of the Hand or Foot.

Theſe Pauſes or Reſts are always equal to the Length or Quantity of the Notes whereto they are annexed, and therefore are called by the ſame Names, as a *Long-Reſt*, *Breve-Reſt*, *Semi-Breve-Reſt*, &c.

PEDESTAL, in Architecture, is a ſquare Body, with a Baſe and Cornice, ſerving as a Foot for the Columns to ſtand upon; it is different in the Orders.

1. The *Tuſcan* Pedeſtal, being the moſt ſimple of all, hath only a Plinth for its Baſe, and an Aſtragal crowned for its Cornice.

2. The *Doric* Pedeſtal (according to *Palladio*) borrowing the *Attic* Baſe, ought to have for its Height $2\frac{1}{3}$ of Diameters of the Column taken before: But no Pedeſtals to this Order are ſeen among the ancient Buildings.

3. The *Ionic* Pedeſtal is two Diameters, and about two thirds high.

4. The *Corinthian* Pedeſtal hath the fourth Part of the Column for its Height, being divided into eight Parts; whereof one muſt be allowed for the Cimaſium, two others for the Baſe, and the reſt for the Dye or Square.

5. The *Compoſite* Pedeſtal ought to have the third Part of the Pillar for its Height.

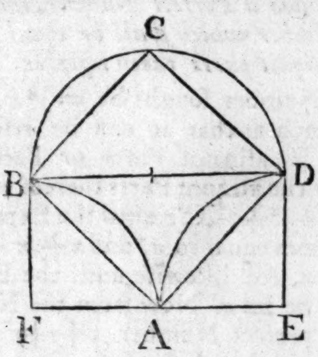
PEDI-

Pediment, in Architecture, is an Ornament that crowns the Ordonnance, finishes the Fronts of Buildings, and serves as a Decoration over Gates, Windows, Niches, &c. it is ordinarily of a triangular Form, but sometimes makes an Arch of a Circle.

Peers, in Architecture, are a kind of Pilasters or Buttresses for Support, Strength, and sometimes Ornament.

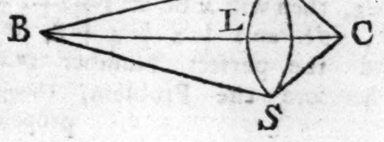
Pegasus, a Constellation in the Northern Hemisphere; containing 23 Stars.

Pelicoides, is the Name given by some to the Figure BCDA, contained under the two inverted Quadrantal Arches AB and AD, and the Semi-Circle BCD, whose



Area = to the Square AC, and that to the Rectangle EB.

Pencil *of Rays*, in Optics, is a double Cone of Rays joined together at the Base; one of which hath its Vertex in some other Point of the Object, and the Glass GLS for its Base; and the other hath its Base on the same Glass, but its Vertex in the Point of Convergence, as at C.



Thus BGSC is a *Pencil of Rays*, and the Line BLC, is called the *Axis of that Pencil.*

Pendulum, is a Weight hanging at the End of a String, Chain, or Wire, by whose Vibrations or Swings to and fro, the Parts or Differences of Time are measured.

1. The Velocities of Pendulums in their lowest Points, are as the Chords of the Arches they fall from or describe.

2. The Lengths of Pendulums (which are always accounted from the Centre of Oscillation, to the Centre of the Ball or Bob) are to each other in a duplicate Ratio of the Times in which their Vibrations are respectively performed; or are as the Squares of the Vibrations performed in one and the same time; wherefore, the Times must be in a subduplicate Ratio of the Lengths. Sir *Isaac Newton* demonstrates, *Cor.* 2. *Prop.* 54. *Princip.* that if the Force of the Movement of a Clock required to keep a Pendulum so adjusted, that the whole Force or Tendency downwards shall be as the Line which arises by dividing the Rectangle under the Semi-Arch of the Vibration and the Radius, is to the Sine of that Semi-Arch, then all the Oscillations shall still be made in the same Space of Time.

3. 'Tis said, that *Ricciolus* was the first that attempted to measure Time by the Pendulum, and therein he was followed, tho' nearly about the same time, by *Langrenus Vendelinus*, *Mersennus*, *Kircherus*, &c. Some of which declare they knew nothing of *Ricciolus*'s Attempt; but the first that applied it to a Movement, Clock, or Watch, was Mr. *Christian Huygens*, and who brought it also to a good Degree of Perfection. See his *Horologium Oscillatorium.*

Pendulums-Royal, are those Clocks,

Clocks, whose Pendulum swings Seconds, and goes eight Days, a Month, *&c.* shewing the Hour, Minutes, and Seconds.

PENINSULA, in Geography, is a Portion of Land, which is almost surrounded with Water, and is joined to the Continent only by an Isthmus, or narrow Neck of Land; as *Africa*, the greatest Peninsula in the World, is joined to *Asia*, and that of the *Morea* to *Greece*, &c

PENTAGON, in Geometry, is a Figure having five Sides, and five Angles: If all the Sides be equal, and also the Angles, it is called a *Regular Pentagon.*

The side of a *Regular Pentagon*, or one which can be inscribed in a Circle, is in power equal to the side of an *Hexagon* and *Decagon*, inscribed in the same Circle.

PENTANGLE, a Figure having five Angles.

PENUMBRA, in Astronomy, is a faint kind of a Shadow, or the utmost Edge of the perfect Shadow, which happens at the Eclipse of the Moon; so that it is very difficult to determine where the Shadow begins, and where the Light ends.

PERAMBULATOR, the same as the *Surveying-Wheel*, is an Instrument made of Wood or Iron, commonly half a pole in Circumference, with a Movement, and a Face divided like a Clock, with a long Rod of Iron or Steel, that goes from the Centre of the Wheel to the Work: There are also two Hands, which (as you drive the Wheel before you) count the Revolutions; and from the Composition of the Movement, and by the Divisions on the Face, shew how many Yards, Poles, Furlongs, and Miles, you go. The Use of this Instrument is to measure Roads, Rivers, and all level Lands, with great expedition.

PERCH, a Measure, by our Statute-Law, of sixteen Foot and a half in length.

PERFECT CONCORDS, in Music; see *Concords.*

PERFECT FIFTH, the same with *Diapente:* which see.

PERFECT NUMBERS, are such whose aliquot, or even parts joined together, will exactly make that whole Number, as 6 and 28, *&c.* For of six, the half is three, the third part two, and the sixth part one, which added together, make six; and it hath no more aliquot parts in whole Numbers; so twenty-eight, which has these parts, *viz.* 14, 7, 4, 2, and 1, exactly make 28; which therefore is a Perfect Number, whereof there are but Ten between One, and one Million of Millions.

To find a Perfect Number, that is, a Number which shall be equal to all its aliquot parts taken together. Let the Number sought be $= y^n x$, being such as that it can be resolved into its aliquot Parts or Factors: Now the aliquot Parts thereof will be $1+y+y^2+y^3$, *&c.* until the Exponent becomes equal to n, and $x+yx+y^2x+y^3x$, &c. likewise until the Exponent be $= n$. Now from the Nature of a perfect Number $1+y+y^2+y^3$, &c. $+x+yx+y^2x+y^3x$, &c may be $= y^n x$; whence $1+y+y^2+y^3$, &c. $= y^n x - x - yx - y^2 x - y^3 x$, &c. and

$$\frac{1+y+y^2+y^3, \&c.}{y^n-1-y-y^2-y^3, \&c.} = x.$$

Now that y may be an Integer (the Number of aliquot parts in any particular Case, if y be expounded by a Number, will not be different from their Number in the general Form) it is necessary that $y^n - y - y^2 - y^3$, &c. be $= 1$; which cannot happen in any other Case, but when $y=2$, then will x be $= 1+2+2^2+2^3$, *&c.* $= 1+2+4+8$, *&c.* and the perfect Number $2^n x$: Therefore the Problem, though proposed

proposed as a kind of indeterminate one, is determinate: If $n=1$, then will $x=1+2=3$, and consequently the perfect Number $2^n x=6$. If $n=2$, then will $x=1+2+4=7$; whence $2^n x=28$: If $n=3$, then will $x=1+2+4+8=15$; therefore $2^n x=120$.

Perigæon, *or* Perigæum, is a Point in the Heavens, wherein a Planet is said to be in its nearest Distance possible from the Earth.

Perihelion, is that point of a planet's Orbit, wherein it is nearest to the Sun.

Perimeter, is the Bounds of any Figure.

Period, in Chronology, signifies a Revolution of a certain Number of Years; as the *Metonic* Period, the *Julian* Period, and the *Calippic* Period: which see in their proper places.

Periodical, is the Term for whatsoever performs its Motion, Course, or Revolution regularly, so as to return again, and to dispatch it always in the same Period, or space of Time. Thus the periodical Motion of the Moon, is that whereby she finishes her Course round about the Earth in a Month; and this is in 27 Days, 7 Hours, 45 Minutes, and is called the *Moon's Periodical Month*; which is the space of Time that the Moon finishes her Revolution in.

Periphery, in Geometry, is the Circumference of a Circle, or of any other Regular Curvilineal Figure.

Periscii, are the Inhabitants of the two frozen Zones, or those that live within the Compass of the *Arctic* and *Antarctic* Circles; for as the Sun never goes down to them after he is once up, but always round about, so do their Shadows. Whence the Name.

Peristyle, in Architecture, is a Place or Building encompassed with Pillars standing round about within the Court: But this word *Peristyle* is sometimes taken for a Row or Rank of Columns, as well without as within any Edifice, as in Cloysters and Galleries. Sometimes this was called *Antiprostyle*.

Peritere, in Architecture, is a place encompassed round with Columns, and with a kind of Wings about it. Here the Pillars stand without, whereas in the Peristyle they stand within.

Peritrochium. See *Axis in Per itrochio*.

Periæci, are those Inhabitants of the Earth, who live under the same parallels, but under opposite Semi-Circles of the Meridian: Whence they have the same Seasons of the Year, *viz.* Spring, Summer, Autumn, and Winter, at the very same Time; as also the same length of Days and Nights; for 'tis in the same Climate, and at an equal Distance from the Æquator: But the Changes of Noon and Midnight are alternate one to the other.

Permutation *of Quantities*. See *Variation* and *Combination*.

Perpendicular, in Geometry, is when a Right Line standeth so upon another, that the Angles on either side are equal; then this Right Line, which so standeth, is perpendicular to that upon which it standeth. A Right Line is said to be

Perpendicular *to a Plane*, when 'tis perpendicular to more than two Lines drawn in that plane. One Plane is perpendicular to another, when a Line in one Plane is perpendicular to the other Plane.

Perpetual Motion. By this Term ought to be meant an uninterrupted Communication of the same Degree of Motion from one part of Matter to another, in a Circle (or such-like Curve returning into itself) so that the same Quantity of

Matter ſhall return perpetually undiminiſhed upon the firſt Mover: And perhaps, if Men had rightly underſtood that this is the true Meaning of a perpetual Motion, Abundance of Expence both of Money and Reputation might have been ſaved, by the vain Pretenders to this piece of impoſſible Mechaniſm.

1. When a Wheel, or other Machine, once ſet in motion, will, without additional Actions on it, continue to move with the ſame, or a greater Velocity, with which it firſt moved, as long as the Matter of which it conſiſts, remains the ſame; ſuch a Motion, by Mechanics, is called *Perpetual.*

2. But ſince Bodies have not in themſelves power to move themſelves, and therefore have not power to increaſe or diminiſh a Motion given them; if they are not acted on by other Bodies, they will continue ſo to move, and with the ſame Velocity: But all revolving Bodies ſuffer Friction with thoſe, by which they are ſuſpended; and the Velocities of thoſe Bodies are therefore continually leſſen'd by the Action of Friction. Therefore, a Wheel, or other Machine, ſet in motion without additional Actions on it, will not continue to move with the ſame Velocity, tho' the Matter of which it conſiſts remains the ſame: But, on the contrary, this Velocity will be continually diminiſhed.

3. Moreover, ſince, by numberleſs Experiments, the moſt polite or burniſh'd Bodies ſliding over one another, loſe all the Motion which hath been given them, and in a ſhort Time: Therefore every Wheel, or any other ſuch Machine will, in a ſhort Time, loſe its Motion.

4. Hence it appears, that the perpetual Motion is not to be expected by a ſingle Wheel.

5. And if any Contrivance cauſes one part of a Wheel to preponderate another; whatſoever is gained by the Deſcent of that preponderating part, will be loſt in its Aſcent; and then the Wheel thus loaded, as ſoon as the Friction hath deſtroyed the Motion given it, will for a while vibrate like other pendulous Bodies, and then at laſt ſtand ſtill. Conſequently no perpetual Motion by Wheel-Work.

PERSEUS, a Conſtellation in the Northern Hemiſphere, conſiſting of 38 Stars.

PERSIC ORDER *of Architecture,* is where the Bodies of Men ſerve inſtead of Columns to ſupport the Entablature; or rather the Columns are in that Form.

The Riſe of it was this: *Pauſanias* having defeated the *Perſians,* the *Lacedemonians,* as a Mark of their Victory, erected Trophies of the Arms of their Enemies, and then repreſented the *Perſians* under the Figures of Slaves, ſupporting their Porches, Arches, or Houſes.

PERSPECTIVE, is an Art that teaches us the Manner of delineating by mathematical Rules; that is, it ſhews us how to draw geometrically upon a plane, the Repreſentations of Objects according to their Dimenſions, and different Situations; in ſuch manner, that the ſaid Repreſentations produce the ſame Effects upon our Eyes, as the Objects whereof they are the Pictures.

Some of the Writers upon *Perſpective* are *Deſargues, de Boſſe, Andrea Albertus, Lamy, Franciſcus Niceron, Pozzo, Ditton, Prick, s'Graveſande, Hamilton,* &c.

PERSPECTIVE AERIAL, is a proportional Diminution of the Lineaments and Colours of a Picture, when the Objects are ſuppoſed to be very remote.

PERSPECTIVE LINEAL, is the Diminution of thoſe Lines in the plane of a Picture, which are the Repreſentations of other Lines very remote.

Perspectine Military, is when the Eye is suppoſed to be infinitely remote from the Table or Plane.

Pertica, a ſort of a Comet; the ſame with *Veru.*

Petard, in Fortification, is an Engine of Metal. in the form of an high-crown'd Hat, with narrow Brims, which being fill'd with very fine Powder, well primed, and then fixed with a Madrier or Plank, bound faſt down, with Ropes running thro' Handles, which are round the Rim of the Mouth of it, ſerves to break down Gates, Port-cullices, Draw-bridges, Barriers, *&c.* This Engine is from 7 to 8 Inches deep, and 5 broad at the Mouth; the Diameter at the Bottom or Breech is an Inch and a half, and the Weight of the whole Maſs of Metal is from 55 to 60 Pounds, generally requiring about 5 Pounds of Powder for the Charge. They are alſo uſed in Countermines, to break through into the Enemy's Galleries, and to diſappoint their Mines.

Phænomenon, in Natural Philoſophy, ſignifies any Appearance, Effect, or Operation of a Natural Body, which offers itſelf to the Conſideration and Solution of an Enquirer into Nature.

Phases, ſignifies the Appearance, or the Manner of Things ſhewing themſelves; and therefore in Aſtronomy is uſed for the ſeveral Poſitions, in which the Planets (eſpecially the Moon) appear to our Sight; as obſcure, horned, half-illuminated, or full of Light, which, by the Help of a Teleſcope, may likewiſe be obſerved in *Venus* and *Mars.*

Phrocyon, a fixed Star of the ſecond Magnitude, in the Conſtellation *Canis Minor,* whoſe Longitude is 111 Degrees, 23 Minutes, Latitude 15 Degrees, 57 Minutes.

Physics, *or* Natural Philosophy, is the ſpeculative Knowledge of all Natural Bodies, and of their proper Natures, Conſtitutions, Powers, and Operations.

Physiology, Physics, *or* Natural Philosophy, is the Science of natural Bodies, and their various Affections, Motions, and Operations. This is either,

1. *General,* which relates to the Properties and Affections of Matter or Body in general. Or,

2. *Special* and *Particular,* which conſiders Matter as formed or diſtinguiſhed into ſuch and ſuch Species, or determinate Combinations.

3. Dr. *Keil,* in his *Introductio ad Phyſicam,* reckons four Claſſes or Sorts of Philoſophers, which have treated of Phyſics or Natural Philoſophy.

4. Thoſe who delivered the Properties of natural Bodies under Geometrical and Numeral Symbols, as the *Pythagoreans* and *Platoniſts.*

5. The *Peripatetics,* who explained the Natures of Things by Matter, Form, and Privation; by elementary and occult Qualities; by Sympathies, Antipathies, Faculties, and Attraction, *&c.* and theſe did not ſo much endeavour to find out the true Reaſons and Cauſes of Things, as to give them proper Names and Terms; ſo that their Phyſics is a kind of Metaphyſics.

6. The *Experimental Philoſophers,* who by frequent and well-made Trials and Experiments, as by Chymiſtry, *&c.* ſought into the Natures and Cauſes of Things: And to theſe almoſt all our Diſcoveries and Improvements are due; and much more would they have done, if they had not fallen into *Theories* and *Hypotheſes,* which they forced oftentimes their Experiments to maintain, whether they could or not.

7. The *Mechanical Philoſophers,* who explicate all the *Phænomena* of Nature by Matter and Motion, by the Texture of Bodies, and the Fi-

gure of their Parts; by *Effluvia*, and other subtile Particles, *&c.* And in short, would account for all Effects and *Phænomena* by the known and established Laws of Motion and Mechanics: And these are, in conjunction with the last named, the only true Philosophers.

PICKET, in Fortification, is sometimes used for a Stake, sharp at one end, to mark out the Ground and Angles of a Fortification, when the Engineer is laying down the Plane of it; these are usually pointed with Iron: There are also larger Pickets, which are drove into the Earth, to hold together Fascines or Faggots, in any Work cast up in haste. And Pickets also are Stakes drove into the Ground by the Tents of the Horse in a Camp, to tie their Horses to. And Pickets were also drove into the Ground before the Tents of the Foot, where they rested their Muskets or Pikes round about them in a Ring. When a Horseman hath committed some considerable Offence, he is often sentenced to stand on the Picket; which is to have one Hand drawn up as high as it can be stretch'd, and then he is to stand on the Point of a Picket or Stake only with the Toe of his opposite Foot; so that he can neither stand or hang well, nor ease himself by changing Feet.

PIEDOUCHE, in Architecture, is a little square Base smoothed, and wrought with Mouldings, which serves to support a Bust or Statue drawn half-way, or any small Figure in Relief.

PIED-DROIT, in Architecture, is a square Pillar differing from a Pilaster in this respect, that it hath no Base or Capital: It is taken also for a Part of the Jaumbs of a Door or Window.

PILASTER, in Architecture, is a kind of a square Column, sometimes standing free, and detach'd from the Wall, but more usually contiguous to it, or let within it, so as it does not shew above one fourth or fifth Part of its Thickness. The Pilaster is different in several Orders, and borrows occasionally the Name of each; having the same Ornaments and the same Proportions with the Columns.

PILLAR, in Architecture, is a kind of a round Column disengaged from any Wall, and made without any proportion; being always either too massive or too slender: Such are the Pillars which support the Vaults of *Gothic* Buildings.

PINION, in a Watch, is that lesser Wheel which plays in the Teeth of another. Its Notches, (which are commonly 4, 5, 6, 8, *&c.*) are called *Leaves*, and not *Teeth*, as in other Wheels.

The Quotient or Number of Turns to be laid upon the Pinion of Report, is found by this Proportion: As the Beats in one Turn of the great Wheel, to the Beats in an Hour: So are the Hours of the Face of the Clock, (*viz.* 12, or 24) to the Quotient of the Hour-Wheel, or Dial-Wheel, divided by the Pinion of Report, *i. e.* the Number of Turns which the Pinion of Report hath in one Turn of the Dial-Wheel.

PIN-WHEEL. See *Striking-Wheel.*

PISCES, is the twelfth and last Sign of the *Zodiac*, being a Constellation consisting of 35 Stars.

PISCIS MERIDIANUS, a *Southern* Constellation containing twelve Stars.

PLACE, is that Part of Space which any Body takes up; and with relation to Space is either absolute or relative; as Mr. *Locke* observes.

2. PLACE, also is sometimes taken for that Portion of infinite Space, which is possessed by, and compre-

hended within the material World, and which is thereby distinguished from the rest of the Expansion.

3. PLACE is usually distinguished into internal Place, which, properly speaking, is that Part of Space which any Body takes up and fills; and External Place, which, according to *Aristotle*, is determined by the Surfaces or Confines of the adjoining or ambient Bodies: But it is better divided into absolute, which is the former internal Place; and into relative Place, which is the apparent secondary or sensible Position of any Body, according to the Determination of our Senses, with respect to other contiguous or adjoining Bodies.

4. *Place of Arms*, when taken in the general, is a strong City which is pitched upon for the Magazine of any Army. But a Place in Fortification usually signifies the Body of a Fortress. And a

5. *Place of Arms in a Garison*, is a large open Spot of Ground in the middle of the City, where the great Streets meet, or else between the Ramparts and the Houses, for the Garison to rendezvous in, upon any sudden alarm, or other occasion. And the

6. *Place of Arms of a Trench*, or *of an Attack*, is a Post near it, sheltered by a Parapet or Epaulement, for Horse or Foot to be at their Arms, to make good the Trenches against the Sallies of the Enemy. These Places of Arms are sometimes covered by a Rideau or Rising-Ground, or else by a Cavin or deep Valley, which saves the trouble of fortifying them by means of Parapets, Fascines, Gabions, &c. they are always open in the Rear, for their better Communication with the Camp. When the Trenches are carried on as far as to the Glacis, they make it very wide, that it may serve for a Place of Arms.

PLACE GEOMETRIC. See *Locus*.

PLACE PLANE. See *Locus Plane*.

PLACE SIMPLE. See *Locus Simple*.

PLACE SOLID. See *Locus Solid*.

PLACE SURSOLID. See *Locus Sursolid*.

PLACE *of the Sun*, *Star*, or *Planet*, is the Sign of the *Zodiac*, Degree, Minute, and Second of it, which the Planet is in; or it is that Degree of the Ecliptic reckoned from the Beginning of *Aries*, which the Planet's or Star's Circle of Longitude cutteth; and therefore is often called the *Longitude of the Sun*, *Planet*, or *Star*.

PLAIN ANGLE. See *Angle*.

1. *Sides of a plain Angle*, are the Lines forming it.

2. *Vertex of any Angle*, are the Points wherein the Lines forming it meet.

3. *Measure of a plain right-lined Angle*, is an Arch of a Circle described about the Vertex, contained between the Sides of the Angle.

4. *Equal right-lined Angles*, are such whereof the Area's of Circles described from their Vertexes, and intercepted between their Sides, are proportional to their Radii, or, which is the same thing, do contain the same Number of Degrees.

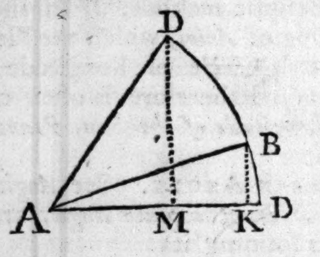
5. *Eucl. in Prop.* 9. *lib.* 1. has taught us how to bisect or divide any given right-lined Angle into two equal Parts, and from thence it will be easy to divide it into 4, 8, 16, 32, 64, &c. equal Parts.

6. But the Ancients, as we learn from *Pappus*, in his Mathematical Collections, could not trisect or divide an Angle given into three equal Parts, by a straight Line and a Circle; and when they found it could not be done this way, they began to consider the Properties of other Curves, and found the thing could be done by the Conchoid, Cissoid,

 or

or *Conic* Sections. But *Archimedes*, *Pappus*, and Sir *Isaac Newton*, approve of the Conchoid for effecting this Business. And,

7. Sir *Isaac Newton*, in *Prob.* 14. *Arit. univer.* shews how to divide an Angle into any given Number of equal Parts, but here the following Equations must be first solved. For if the given Angle be DAD, and BAD be the sought Angle that is to be any given Part thereof,



and the Radius AD be called r, the Sine DM of the given Angle q, and the Sine Complement AK of the sought Angle x: Then the Bisection of the given Angle will be had by the Resolution of this Equation, $xx-2rr=qr$; the Trisection by the Resolution of this $xxx-3rrx=qr^2$; the Quadrisection, by the Resolution of this $x^4-4rrxx+2r^4=qr^3$; the Quinquisection, by the Resolution of this $x^5-5r^2x^3+5r^4x=qr^45$, &c.

Plain Chart, is the Plot or Chart, that Seamen sail by, whose Degrees of Longitude and Latitude are made of the same Length.

Plain Sailing, is the Art of finding all the Varieties of the Ship's Motion on a Plane, where all the Meridians are made parallel, and the Parallels at Right Angles with the Meridians, and the Degrees of each Parallel equal to those of the Equinoctial; which tho' notoriously false in itself, supposing the Earth and Sea to be a plane Flatness, and each Parallel equal to the Equinoctial; yet by laying down Places accordingly, and breaking a long Voyage into many short ones, a Voyage may pretty well be performed by it near the same Meridian.

In plain Sailing 'tis imagined, that by the Rhumb-Line, Meridian, and Parallel of Latitude, there always will be formed a right-angled Triangle; and that so posited, as that the Perpendicular may represent part of the Meridian or *North* and *South* Line, containing the Difference of Latitude: The Base of the Triangle represents the Departure, and the Hypotheneuse the Distance sailed; the Angle at the top is the Course, and the Angle at the Base the Complement of the Course; any two of which, with the Right Angle being given, the Triangle may be protracted, and the other three Parts found.

Plain Scale, is a thin Ruler, either of Wood or Brass, whereon are graduated the Lines of Chords, Sines, Tangents, Secants, Leagues, Rhumbs, &c. and is of ready Use in most Parts of the Mathematics, chiefly in Navigation.

Plain Table, is an Instrument used in surveying of Land.

1. The Table itself is a Parallelogram of Wood, 14 Inches and a half long, and 11 Inches broad, or thereabouts.

2. A Frame of Wood fixed to it, so as a Sheet of Paper being laid on the Table, and the Frame being forced down upon it, squeezeth in all the Edges, and makes it lie firm and even, so as a Plot may be conveniently drawn upon it. Upon one side of this Frame should be equal Divisions for drawing parallel Lines both long-ways and cross-ways (as occasion may require) over your Paper; and on the other side the 360 Degrees of a Circle, projected from a Brass Centre

tre conveniently placed in the Table.

3 A Box with a Needle and Card, to be fixed with two Screws to the Table; very useful for placing the Instrument in the same position upon every Remove.

4. A three-legged Staff to support it, the Head being made so as to fill the Socket of the Table, yet so as the Table may be easily turn'd round upon it, when 'tis fixed by the Screw.

5. An Index, which is a large Ruler of Wood, (or Brass) at the least 16 Inches long, and 2 Inches broad, and so thick as to make it strong and firm; having a sloped Edge, call'd the *Fiducial Edge*, and two Sights of one Height, (whereof the one hath a Slit above, and a Thread below, and the other a Slit below and a Thread above) so set in the Ruler, as to be perfectly of the same Distance from the Fiducial Edge. Upon this Index 'tis usual to have many Scales of equal Parts, as also Diagonals, and Lines of Cords.

PLANCERE, in Architecture, is the under part of the Roof of a Corona; which is the superior part of the Cornice, between two Cimasiums. See those Words.

PLANE *of a Dial*, is the Surface on which any Dial is supposed to be described.

PLANE GEOMETRICAL, *in Perspective*, is a plane Surface, parallel to the Horizon, placed lower than the Eye; wherein the visible Objects are imagined without any Alteration, except that they are sometimes reduced from a greater to a lesser size.

PLANE HORIZONTAL, in perspective is a Plane which is parallel to the Horizon, and which passes thro' the Eye, or hath the Eye supposed to be placed in it.

PLANE *of Gravitation*, or *Gravity in any heavy Body*, is a Plane supposed to pass thro' the Centre of Gravity of it.

PLANE, in Fortification, is the Representation of a Work in its Height and Breadth.

PLANE *of the Horopter, in Optics*, is that which passeth thro' the Horopter, and is perpendicular to the Plane of the two optical Axes.

PLANE NUMBER, is that which may be produced by the Multiplication of two Numbers one by another; thus 6 is a plane Number, because it may be produc'd by the Multiplication of 3 by 2; for twice 3 makes 6. So also 15 is a plane Number, arising from 5 being multiply'd by 3: And 9 is a plane Number, produc'd by the Multiplication of 3 by 3.

PLANE PROBLEM, in Mathematics, is such an one as can be solved geometrically by the Intersection either of a Right Line and a Circle, or of the Circumferences of two Circles: As having the greater Side given, and the Sum of the other two, of a right-angled Triangle; to find the Triangle: To describe a Trapezium that shall make a given Area of four given Lines.

PLANE *of Reflection, in Catoptrics*, is that which passes thro' the Point of Reflection, and is always perpendicular to the Plane of the Glass, or reflecting Body.

PLANE *of Refraction*, is a Surface drawn thro' the incident and refracted Ray.

PLANE SURFACE, is that which lies evenly between its bounding Lines; and as a Right Line is the shortest Extension from one Point to another, so a plain Surface is the shortest Extension from one Line to another.

PLANE VERTICAL, in Optics and

and Perſpective, is a plane Surface which paſſeth along the principal Ray, and conſequently thro' the Eye, and is perpendicular to the geometrical Plane.

PLANETS, are the erratic, or wandering Stars, and which are not like the fixed ones always in the ſame poſition to one another. We now number the Earth among the primary Planets, becauſe we know it moves round the Sun, as *Saturn*, *Jupiter*, *Mars*, *Venus*, and *Mercury* do; and that in a Path or Circle between *Mars* and *Venus*. And the Moon is accounted among the ſecondary Planets, or Satellites of the primary, ſince ſhe moves round the Earth, as *Jupiter*'s four Moons or Satellites do round him, and *Saturn*'s five round him; if *Caſſini*'s Eyes may be credited. But I could never ſee my ſelf, or meet with any body elſe, who ever did ſee any but the *Huygenian Satellites*.

PLANIMETRY, the ſame with *Planometria*. Which ſee.

PLANISPHERE, ſignifies the Circles of the Sphere deſcrib'd *in plano*, or on a Plane; or it is a plane or flat Projection of the Sphere. And thus the Maps either of Heaven or Earth are called *Planiſpheres*; as alſo other aſtrolabical Inſtruments. And all Charts or Maps for the Uſe of Mariners, are call'd the *Nautical Planiſpheres*. See *Nautical Planiſphere*.

PLAT-BASTION. See *Baſtion*.

PLAT-BAND, in Architecture, is a ſquare Moulding, having leſs Projecture than Height: Such are the Faces of an Architrave, and the Plat-Band of the Modillions of a Cornice.

PLATFORM, in Fortification, is a Place prepared on the Ramparts for the raiſing of a Battery of Cannon; or it is the whole Piece of Fortification raiſed in a re-entring Angle. See *Battery*.

PLATFORM, in Architecture, is a Row of Beams that ſupport the Timber-Work of a Roof, and lie on the top of the Wall, where the Entablature ought to be raiſed. Alſo a kind of Terraſs-Walk, or even Floor on the top of a Building; from whence we may take a fair proſpect of the adjacent Gardens or Fields: So an Edifice is ſaid to be covered with a Platform, when it hath no arched Roof.

PLATONIC BODIES. See *Regular Bodies*.

PLEIADES, the ſame with thoſe ſeven Stars in the Neck of the Bull, which are uſually thus called.

PLINTH, in Architecture, is a ſquare Piece, or Table, under the Mouldings of the Baſes of Columns and Pedeſtals.

PLOW, is an Inſtrument made of Pear-tree, uſed by Seamen to take the Height of the Sun or Stars, in order to find the Latitude: It admits of the Degrees to be very large, and is much eſteem'd by many Artiſts.

PLUMB-LINE, the ſame with *Perpendicular*.

PNEUMATICS, is the Doctrine of the Gravitation and Preſſure of elaſtic or compreſſible Fluids.

PNEUMATIC ENGINE, the ſame with the *Air-Pump*.

POETICAL, Riſing and Setting of the Stars: This is peculiar to the ancient poetical Writers; for they refer the Riſing and Setting of the Stars, always to that of the Sun; and accordingly make three ſorts of poetical Riſings and Settings; *Coſmical*, *Acronical*, (or as ſome write it, *Acronyctal*,) and *Heliacal*. See thoſe Words.

POINT, in Geometry, is that which is ſuppoſed to have neither Breadth, Length, or Thickneſs, but is indiviſible.

1. The Ends or Extremities of Lines are Points.

2. If a Point be ſuppoſed to be moved any way, it will by its Motion deſcribe a Line.

Point-Blank, a Term in Gunnery, ſignifying that a Shot or Bullet goes directly forward to the Mark, and doth not move in a Curve as Bombs and highly elevated Random-Shots do.

Point *of the Compaſs*, in Navigation, ſignifies 11 Degrees and 15 Minutes, or one 32d Part of the Compaſs: The half of which is 5 Degrees and 38 Minutes, which they call a *Half-Point*; and the half of this, which is 2 Degrees and 49 Minutes, they call a *Quarter-Point*.

The Seamen alſo call the Extremity of any Promontory, (which is a Piece of Land running out into the Sea) a *Point*; which is of much the ſame ſenſe with them as the word *Cape*.

They ſay two Points of Land are one in another, when the innermoſt is hinder'd from being ſeen by the outermoſt.

Point *of Concourſe* in Optics, is that Point where the viſual Rays, being reciprocally inclined, and ſufficiently prolonged, meet together, are united in the middle, and croſs the Axis. This Point is moſt uſually called the *Focus*; and ſometimes *the Point of Convergence*.

Point *of Concurrence*, a Term in Perſpective. See *Principal Point*.

Point *of Divergence*. See *Virtual Focus*.

Point *of Diſtance*, is a Point in the Horizontal Line, ſo far diſtant from the principal Point as the Eye is remote from the ſame.

Point *of Sight*. See *Principal Point*.

Point *of Incidence*, in Optics, is that Point on the Surface of a Glaſs, or other Body, on which any Ray of Light falls: And as ſome expreſs themſelves, it is that Point of the Glaſs, which a Ray parts from, after its Refraction, and when 'tis returning into the Rare Medium again.

Point *of Inflexion of a Curve*. See *Inflexion*.

Polar Dials, are thoſe whoſe Planes are parallel to ſome great Circle that paſſes thro' the Poles, or parallel to ſome one of the Hour-Circles; ſo that the Pole is neither elevated above, nor depreſſed below the Plane: Therefore the Dial can have no Centre, and conſequently its Stile, Subſtile, and Hour-Lines, are parallel. This therefore will be an Horizontal Dial to thoſe that live under the Equator or Line.

1. In a direct polar Dial, the Hour-Lines muſt be drawn all parallel to the Hour-Line of Twelve.

2. The Style may be either a ſtraight Pin ſet upright, or a Wire made to lie parallel to the Plane; and muſt ſtand over the Hour-Line of Twelve.

3. The Length of the Plane may be taken in any Inches, or Parts of Inches, reckoning the Inch to be divided into 10, or 100 equal Parts of the Style.

4. Then for the Height.

As the Tangent of the Hour-Line 4 or 5, turned into Degrees, is to the Logarithm of their Diſtance from the Meridian in Inches, and Parts: So is the Radius to the Height of the Stile in Inches and Parts.

5. For the Hour-Lines.

As the Radius is to the Logarithm of the Stile's Height, in Parts of Inches: So is the Tangent of any Hour-Line, to the Logarithm of the Diſtance thereof from the Meridian-Line.

Polar Projection, is a Repreſentation of the Earth, or of the Heavens projected on the Plane of one of the Polar Circles.

Polarity, is the Property of the

the Magnet, or of a Piece of oblong Iron touched by a Magnet, to point towards the Poles of the World.

Pole, *in Measuring*, is the same with *Perch* or *Rod*.

Pole, *in Mathematics*, is a Point 90 Degrees distant from the Plane of any Circle, and in a Line perpendicularly erected in its Centre; which Line is called the *Axis*. And from this polar Point may Circles be described on the Globe or Sphere, as they are on a Plane from their Centre.

Pole-Star, is a Star in the Tail of the little Bear, (a Constellation of seven Stars, which is called *Cynosura*,) and is very near the exact *North* Pole of the World.

Pole *of a Glass*, in Optics, is the thickest Part of a Convex, but the thinnest of a Concave Glass; and if the Glass be truly ground, will be exactly in the middle of its Surface. This is sometimes called the *Vertex of the Glass*.

Poles *of the World*, are two Points in the Axis of the Æquator, each 90 Degrees distant from its Plane; one pointing North, which therefore is called ahe *North* or *Arctic Pole*; the other Southward, which therefore is called the *South*, or *Antarctic Pole*.

Whether any People live directly under the Pole, or not, is a Question; but Dr. *Halley* hath proved, that the solstitial Day under the Pole, is as hot as under the Equinoctial, when the Sun is vertical to them, or in their Zenith; because for all the 24 Hours of that Day under the Pole, the Sun's Beams are inclin'd to the Horizon with an Angle of 23 ½ Degrees: Whereas under the Equinoctial, tho' he becomes vertical, yet he shines no more than 12 Hours, and is absent 12 Hours. And besides, for three Hours eight Minutes of that 12 Hours, he is above the Horizon there; but is not so much elevated as under the Pole.

Poles *of the Ecliptic*, are Points in the solstitial Colure 23 Degrees and 30 Minutes distant from the Poles of the World; and thro' these all Circles of Longitude in the Heavens do pass, as the Hour-Circles do thro' the Poles of the Æquator.

Pollux, a fixed Star in the Twins, of the second Magnitude, whose Longitude is 108 Degrees and 47 Minutes, Latitude 6 Degrees and 38 Minutes.

Polyacousticks, are Instruments contrived to multiply Sounds, as Multiplying-Glasses or Polyscopes do Images of Objects.

Polyedron, the same with *Polyhedron*.

Polygon, a Term in Geometry, signifying in the general any Figure of many Sides and Angles, tho' no Figure is called by that Name, unless it have more than four or five Sides.

1. Every Polygon may be divided into as many Triangles as it hath Sides.

2. The Angles of any Polygon taken together, will make twice as many right ones, except four, as the Figure hath Sides.

3. Every Polygon circumscribed about a Circle, is equal to a rectangled Triangle, one of whose Legs shall be the Radius of the Circle, and the other the Perimeter (or Sum of all the Sides) of the Polygon.

If you make a Table, wherein the first horizontal Row being 1, and the second $z - 1$; let the third $zz - z - 1$ be equal to the Product of the second by z less the first; the fourth $z^3 - zz - 2z + 1$, equal to the Product of the third by z, less the second, and so on: And then form an Equation, one side of which being nothing, let the other be

be that horizontal Row of Quantities in the Table, whose Exponent is half the Number of Sides of a Polygon *plus* 1: I say, the greatest Root z of this Equation shall terminate an Arc, whose Chord shall be the Side of a Polygon, whose Number of Sides are express'd by the first upright Row of Numbers.

A Table for the Inscription of regular Polygons in a Circle.

1	1
2	$z - 1$
3	$zz - z - 1$
4	$z^3 - zz - 2z + 1$
5	$z^4 - z^3 - 3zz + 2z + 1$
6	$z^5 - z^4 - 4z^3 + 3zz + 3z - 1$
7	$z^6 - z^5 - 5z^4 + 4z^3 + 6zz - 3z - 1$
8	$z^7 - z^6 - 6z^5 + 5z^4 + 10z^3 - 6zz - 4z + 1$
9	$z^8 - z^7 - 7z^6 + 6z^5 + 15z^4 - 10z^3 - 10zz + 4z + 1$

For Example, if it be required to inscribe an Heptagon in a Circle: Take the 4th horizontal Row of Quantities in the Table, because four is greater than half seven by *plus* 1, and making it equal to nothing, we have $z^3 - zz - 2z + 1 = o$, and the greatest Root z of this Equation shall express the Value of the Chord terminating an Arch, being the seventh Part of the whole Circumference.

If the Radius of a Circle be $= 1$, and z be the Length of the Side of a regular Polygon inscribed in that Circle, and in general $m + 1$ be equal to half the Number of Sides of the Polygon, which is supposed to be odd; then will

$$o = z - z^{m-1} - \overline{m-1}\,z^{m-2} + m - 2z^{m-3} + \frac{m-3}{1} \times \frac{m-2}{2} z^{m-4} - \frac{m-4}{1} \times \frac{m-3}{2} z^{m-5} - \frac{m-5}{1} \times \frac{m-4}{2} \times \frac{m-3}{3} z^{m-6} + \frac{m-6}{1} \times \frac{m-5}{2} \times \frac{m-4}{3} z^{m-7} + \frac{m-7}{1} \times \frac{m-6}{2} \times \frac{m-5}{3} \times \frac{m-4}{4} z^{m-8},\ \&c.$$

be a general Equation for finding the Side of a regular Polygon in a Circle; of which the same Number of Terms must be taken, as there are Units in $m + 1$; what follows being equal to o: For Example, let 7 be the Number of Sides of the Polygon to be inscribed; then will $m = 3$, and so $z^3 - zz - 2z + 1 = o$; and the greatest Root z of this Equation will be the Length of the Side of the Heptagon.

There are several other curious Theorems relating to the Chords and Polygons in Circles to be found at the End of the 10th Book of the Marquis *de l'Hospital's Analytic Treatise of Conic Sections.*

POLYGON EXTERIOR, in Fortification, is the Distance of one Point of a Bastion from the Point of another, reckon'd all round the Work.

POLYGON INTERIOR, is the Distance between the Centres of any two Bastions, reckoned all round as before.

POLYGONAL NUMBERS, are such as are the Sums or Aggregates of Series of Numbers in Arithmetical Progression, beginning with Unity; and so placed that they represent the Form of a Polygon. Thus,

1 3 6 10

are

are triangular Numbers, because they are the Aggregates of a certain Number of Points plac'd in the Form of Triangles, *&c.*

. . . .
. . .   .
. .   . .
.   . .   .

1 4 9 16

are Quadrangular Numbers, *&c.*

If the Side of a Polygonal Number be $=n$, and the Number of Angles be $=a$, and the first Term $=1$; then the Sum of a Series of Triangular Numbers will be,

Triangular $\dfrac{n^3+3n^2+2n.}{6}$

Of Pentagonal, $\dfrac{n^3+n^2.}{2}$

Of Hexagonal, $\dfrac{4n^3+3n^2-n.}{6}$

Of Septagonal, $\dfrac{5n^3+3n^2-2n.}{6}$

Of Octogonal, $\dfrac{2n^3+n^2-n.}{2}$

POLYGRAM, is a Geometrical Figure consisting of many Lines.

POLYHEDROUS FIGURE, in Geometry, is a Solid contained under or consisting of many Sides; which if they are regular Polygons, all similar and equal, and the Body be inscribable within the Surface of a Sphere, 'tis then call'd a *Regular Body.* See that Word.

POLYNOMIAL, *or Multinomial Roots*, in Mathematicks, are such as are compos'd of many Names, Parts, or Members; as $a+b+d+e$.

POLYSCOPES, *or Multiplying Glasses*, are such as represent to the Eye one Object as many.

POLYSPASTIUM, a Term in Mechanicks, the same with the Trochlea or Pulley.

PONTON, in Fortification, is a Bridge made of Two Boats, at some distance one from another, both cover'd with Planks; as also the internal Space betwixt them. They have Props and Rails on each side; and the whole Structure ought to be solid, as to be able to transport the Horse, together with Cannon and Baggage, as well as the Infantry.

PONT-VOLANT, *or the Flying Bridge used in Sieges*, is made of two small Bridges laid one over another, and so contrived by the means of Cords and Pulleys placed along the Sides of the Under Bridge, that the Upper can be push'd forwards till it joins the Place where it is to be fix'd; but however the whole Length of both these Bridges must not be above four or five Fathom long, lest they should break with the Weight of the Men. These are chiefly used to surprize Outworks or Posts that have but narrow Moats.

PORES, are small Interstices, Spaces or Vacuities between the Particles of Matter that constitute every Body, or between certain Aggregates or Combinations of them.

Mr. *Boyle* has written a particular Essay on the Porosity of Bodies, in which he proves, that the most solid Bodies that are, have some kind of Pores: And indeed, if they had not, all Bodies would be alike specifically weighty.

PORIME, (*Gr.* πόριμα) in Geometry, is a Theorem, or Proposition so easy to be demonstrated, that 'tis almost self-evident; as, that a Chord is all of it within the Circle. And on the contrary, they call that an *Aporime*, which is so difficult as to be almost impossible to be demonstrated; as the squaring of any assign'd Portion of *Hippocrates*'s *Lunes* was, till a little while ago.

PORISME. *Proclus* and *Pappus* define this Geometrical Term to signify a kind of Theorem, in the Form of a Corollary, which is dependant upon, or deduced from some other Theorem already demonstrated.

ſtrated. And 'tis commonly uſed to ſignify ſome general Theorem, which is diſcover'd from finding out ſome Geometrical Place, or Locus: As, for inſtance: If a Man hath found out by Algebra, or any other Method, how to conſtruct a Local Problem; and from that Place ſo conſtructed and demonſtrated, hath deduc'd ſome general Theorem, that Theorem is by the Geometrick Writers call'd a *Poriſme*.

Poristick Method, in Mathematicks, is that which determines when, by what Way, and how many different Ways a Problem may be reſolved.

Portcullice, *Herſe, or Sarazine*, in Fortification, ſignifies ſeveral great Pieces of Wood laid or join'd acroſs one another like an Harſon, and at the Bottom it is pointed at the End of each Bar with Iron; theſe formerly uſed to hang over the Gate-ways of fortify'd Places, to be ready to let down in caſe of a Surprize, when the Enemy ſhould come ſo ſoon, as that there is no Time to ſhut up the Gates: But now a-days the Orgues are more generally uſed, as being found to be much better. See *Orgues*.

Portico, in Architecture, is a kind of Gallery raiſed upon Arches, where People walk under Shelter. It has ſometimes a Soffit or Ceiling, but is more commonly vaulted. Though the word *Portico* be deriv'd from *Port* or *Gate*, yet do we call the whole Diſpoſition of the Columns in the Gallery by this Name. The moſt celebrated Portico's of Antiquity were thoſe of the Temple of *Solomon*, that of *Athens* built for the People to divert themſelves in, and where the Philoſophers held their Converſation, that which occaſion'd the Diſciples of *Zeno* to be call'd *Stoicks* from the *Greek Stoa*, a Portico: That magnificent one of *Pompey* at *Rome*, and that of St. *Peter*'s Palace in the Vatican.

Position, *or* Site, is an Affection of Place, and expreſſes the Manner of any Body's being in a Place: This therefore is not Place, nor indeed hath it any Quantity; as Sir *Iſaac Newton* well obſerves in *Princip. Mathem p.* 1.

Position, *or the* Rule of Poſition, *otherwiſe called the* Rule of Falſhood, is a Rule in Arithmetick, wherein any Number is taken to work the Queſtion by, inſtead of the Number ſought; and ſo by the Error or Errors found, we find the Number required.

This Rule of falſe Poſition is of two Kinds, *viz.* Single and Double.

Position Single, is when there happens in the Propoſition ſome Partition of Numbers into Parts proportional, and then at one Operation the Queſtion may be reſolved by this Rule:

Imagine a Number at pleaſure, and work therewith according to the Tenor of the Queſtion; as if it were the true Number; and what Proportion there is between the falſe Concluſion, and the falſe Poſition; ſuch Proportion hath the given Number to the Number ſought: Therefore the Number found by Argumentation ſhall be the firſt Term of the *Rule of Three*, and the Number ſuppoſed ſhall be the ſecond Term, and the given Number ſhall be the third Term.

Position Double, is when there can be no Partition in the Numbers to make a Proportion: Therefore, you muſt make a Suppoſition twice, proceeding therein according to the Tenor of the Queſtion; and if either of the ſuppoſed Numbers happens to ſolve the Propoſition, the Work is done; but if not, obſerve the Errors, and whether they be greater or leſſer than the Reſolution requireth;

requireth; and mark the Errors accordingly, with the Signs + or —.

Then multiply contrariwise the one Position by the other Error; and if the Errors be both too great, or both too little, substract the one Product from the other, and the one Error from the other, and divide the Difference of the Products by the Difference of the Errors.

But, if the Errors be unlike, as the one +, and the other —, add the Products, and divide the Sum thereof by the Sum of the Errors added together: For the Proportion of the Errors, is the same with the Proportion of the Excesses or Defects of the Numbers supposed, to the Numbers sought.

POSITIVE QUANTITIES, in Algebra, are such as are of a real and affirmative Nature, and either have, or are supposed to have the affirmative or positive Sign + before them, and 'tis always used in opposition to the negative Quantities, which are defective, and have this Sign — before them.

POSTERN, in Fortification, is a False-Door usually made in the Angle of the Flank, and of the Curtain, or near the Orillon, for private Sallies.

POSTICUM, is the Postern-Gate, or Back-Door of any Fabric.

POSTULATES, or DEMANDS, in Mathematics, *&c.* are such easy and self-evident Suppositions, as need no Explication or Illustration to render them intelligible. As,

That a Right Line may be drawn from one Point to another. That a Circle may be described on any Centre given, of any Magnitude, *&c.*

POTANS, or POTENCE, a Part of a Watch; see under *Ballance*.

POWERS, in Algebra, are Numbers arising from the Squaring or Multiplication of any Number or Quantity by it self, and then that Product by the Root or first Number again; and this third Product by the Root again; and so on *ad infinitum*; as 2, 4, 8, 16, 32, 64, 128, 256, *&c.* Where 2 is called the Root or first Power, 4 is its Square or second Power, 8 is its Cube or third Power, 16 its Biquadrate or fourth Power, *&c.* And these Powers in Letters or Species, are expressed by repeating the Root as often as the Index of the Power expresses; thus, a is the Root or first Power, aa the Square or second Power, aaa the Cube, $aaaa$ the Biquadrate or fourth Power. And to avoid the tediousness of repeating the Root so often when the Powers are high, we only put down the Root with the Index of the Power over it, thus; a^9, that is the ninth Power of a; b^{16}, b^{94}, are the sixteenth and the ninety-fourth Powers of b.

POWER *of an* HYPERBOLA, is the 16th Part of the Square of the conjugate Axis, or the $\frac{1}{4}$ Part of the Square of the semi-conjugate Axis; or it is equal to a Rectangle under the $\frac{1}{4}$ of the transverse Axis, and $\frac{1}{4}$ Part of the Sum of the transverse Axis, and Parameter.

POWERS *of* LINES, or Quantities, are their Squares, Cubes, *&c.* or other Multiplications of the Parts into the whole, or of one Part into another.

PRACTICE, in Arithmetic, is a Rule which expeditiously and commodiously answers Questions in the *Rule of Three*, when the first Term is 1, or Unity; and 'tis so called from its Readiness in the Practice of Trade and Merchandize.

PRECESSION *of the Equinox.* Because in reality the Axis of the Earth doth a little vary from such an exact Parallelism, and doth not point always precisely to the same Star, when it is in the same place; hence it happens that the Equinoctial Points, or the common Intersection

ſection of the Equator and Ecliptic, do retrocede or move backward from Eaſt to Weſt, about 50 Seconds each Year; and this Motion backwards is by ſome called the *Receſſion of the Equinox*, by others the *Retroceſſion*; and the advancing of the Equinoxes forward by this means is called the *Preceſſion* of them.

PRELUDE, in Muſic, ſignifies any Flouriſh that is introductory to Muſic, which is to follow after.

PRIEST'S CAP, a Term in Fortification. See *Bonnet a Pretre*.

PRICK. To prick the Chart or Plot at Sea, ſignifies to make a Point in their Chart whereabout the Ship is now, or is to be at ſuch a time, in order to find the Courſe they are to ſteer, *&c.*

PRIMARY PLANETS, are thoſe ſix that revolve about the Sun, *viz. Mercury*, *Venus*, *the Earth*, *Mars*, *Jupiter*, and *Saturn*.

PRIME FIGURE, is that which cannot be divided into any other Figures more ſimple than itſelf; as a Triangle in Planes, the Pyramid in Solids: For all Planes are made of the firſt, and all Bodies or Solids compounded of the ſecond.

PRIME NUMBERS, in Arithmetic, are thoſe made only by Addition, or the Collection of Units, and not by Multiplication: So an Unit only can meaſure them; as 2, 3, 4, 5, *&c.* and is by ſome called a *ſimple*, and by others an *uncompound Number*.

PRIME VERTICALS, *or Direct*, *Erect*, *North*, *or South Dials*, are thoſe whoſe Planes lie parallel to the prime vertical Circle, which is that Circle perpendicular to the Horizon, and paſſing thro' the Eaſt and Weſt Points of it.

PRIMING-IRON, is a ſmall ſharp Iron which is thruſt into the Touch-hole of a great Gun, and pierces into the Cartridge that holds the Powder or Touch-Powder to fire off the Piece.

PRIMUM MOBILE, in the *Ptolemaic Aſtronomy*, is ſuppoſed to be a vaſt Sphere, whoſe Centre is that of the World, and in compariſon of which the Earth is but a Point: This they will have to contain all other Spheres within it, and to give motion to them, turning itſelf and all of them quite round in twenty-four Hours.

PRINCIPAL RAY, in Perſpective, is the perpendicular one which goes from the Spectator's Eye to the vertical Plane, or the Picture. And the Point where this Ray falls on the Picture, is called from hence, the

PRINCIPAL POINT, and is that Point of the Picture wherein a Ray drawn perpendicular to it, cuts it.

PRISM, is a ſolid Figure, contained under ſeveral Planes, whoſe Baſes are Polygons, equal, parallel, and alike ſituated.

1. *Priſm in Optics*, is a Glaſs bounded with two equal and parallel triangular Ends, and three plane and well poliſhed Sides, which meet in three parallel Lines, running from the three Angles of one End, to thoſe of the other, and is uſed in Optics to make many noble and curious Experiments about Light and Colours: For the Rays of the Sun falling upon it at a certain Angle, do tranſmit thro' it a Spectrum or Appearance, coloured like the Iris or Rainbow in the Heavens.

2. The Surface of a right Priſm, is equal to a Parallelogram of the ſame Height, having for its Baſe a right Line equal to the Periphery of the Priſm.

3. All Priſms are to one another in a Ratio compounded of their Baſes and Heights.

4. All like Priſms are to one another in the triplicate Ratio of their anſwerable Sides.

5.

5. A Prism is the triple of a Pyramid of the same Base and Height.

PRISMOID, is a solid Figure, contained under several Planes whose Bases are rectangular Parallelograms parallel and alike situate.

PROBLEM, is a Proposition which relates to Practice; or which proposes something to be done: As to make a Circle pass through three given Points not lying in a right Line, &c.

PRODUCE, a Term in Geometry, signifying to continue a right Line, or draw it out farther, till it has any assigned Length.

PRODUCT, is the Quantity arising from, or produced by the Multiplication of two or more Numbers, Lines, &c. into one another; thus, if 6 be multiplied by 8, the Product is 48. In Lines, 'tis always, (and sometimes in Numbers,) called the *Rectangle* between the two Lines that are multiplied one by another. See *Rectangle*.

PROFILE, in Architecture, is the Contour or Out-line of any Member, as that of the Base, Cornice, or the like. Or it is more properly a Prospect of any Place, City, or Piece of Architecture, viewed side-ways, and expressed according to the Rules of Perspective.

PROGRESSION ARITHMETICAL. See *Arithmetical Progression*.

PROGRESSION GEOMETRICAL, or *Geometrical Proportion continued*, is when Numbers, or other Quantities, proceed by equal Proportion or Ratio's, (properly called,) that is, according to one common Ratio whether increasing or decreasing. As,

1, 2, 4, 8, 16, 32, 64, &c.

2. If there are never so many continual Proportionals, the Product of any two Extremes is equal to the Product of any two Means that are equally distant from the Extremes, as also to the Square of the Mean, or middle Term, if the Number of the Terms be odd.

3. If the first and last Terms, and the Ratio in any Geometrical Progression be given, and the Sum of all the Terms be required, multiply the second and last Terms together, and from the Product substract the Square of the first Term; and then divide the Remainder by the Difference between the first and second Term, and the Quotient will be the Sum of all the Terms.

4. Any infinite Series of Fractions decreasing according to the Proportion of the Denominator of the last Term, and having a common Numerator less by an Unit than the Denominator of the last Term, is equal to Unity.

PROJECTILES, are such Bodies as being put into a violent Motion by any great Force, are then cast off or let go from the Place where they received their Quantity of Motion, and do afterwards move at a distance from it; as a Stone thrown out of one's Hand by a Sling, an Arrow from a Bow, a Bullet from a Gun, &c.

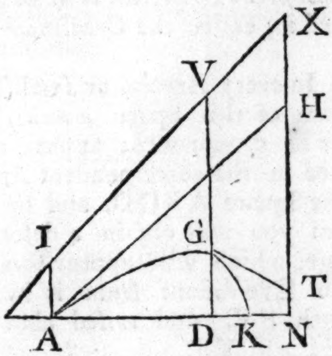
1. The Line of Motion which a Body projected describes, abstracting from the Resistance of the Medium, is, as hath been proved by *Gallileus*, and many others, and particularly by Sir *Isaac Newton*, Prop. 4. Cor. 1. of his Second Book, the Curve of a Parabola, which Line is also described by every descending Body. He shews also, that if the Line of Direction of the projectile Motion of any Body, the Degree of its Velocity, and at the Beginning, the Resistance of the Medium being given, the Curve which it will describe may be discovered, and *vice versa*. He saith also in *Schol. Prop.* X. *Lib.* 2. that the Line which a Projectile describes in a Medium uniformly resisting the Motion, rather approaches to an Hyperbola than a Parabola.

2. The

2. The horizontal Distances of Projections made with the same Velocity at several Elevations of the Line of Direction, are as the Sines of the double Angles of Elevation.

3. The Velocities of Projectiles, in the several Points of a Curve, are as the Lengths of the Tangents to the Parabola in those Points, intercepted between any two Diameters: And these again are as the Secants of the Angles, which those Tangents continued make with the horizontal Line.

4. If AGK be a Curve of the hyperbolic kind, one of whose Asymptotes is NX, perpendicular to the Horizon AK, and the other IX inclin'd to the same, where VG is reciprocally as DN^n whose Index is n: This Curve will nearer represent the Path of a Projectile thrown in the Direction AH in our Air,



(which may be taken as a uniform Medium, resisting Bodies as the Squares of their Velocities,) than a Parabola which is only describ'd by a Projectile, where there is no Medium resisting its Motion. Sir *Isaac Newton*, in the second Book of his *Principia*, says indeed, That these Hyperbola's are not accurately the Curves that a Projectile makes in the Air; for the true ones are Curves which about the Vertex are more distant from the Asymptotes, and in those Parts remote from the Axis approach nearer to the Asymptotes than these Hyperbola's; but in Practice these Hyperbola's may be used instead of those more compounded ones. And if a Body be projected from the Place A, according to the right Line AH, and AI be drawn parallel to the Asymptote NX, and GT is a Tangent to the Curve, (in the Vertex:) Then the Density of the Medium in A will be reciprocally as the Tangent AH, which if it had been a standing Quantity, the Medium would have had a given Density as our Air may be said to have, so far as Projectiles can move in it, and the Body's Velocity will be as $\sqrt{\frac{AH^2}{AI}}$, and the Resistance thence to Gravity, as AH to $\frac{2nn+2n}{2+n} \times AI$.

The Doctrine of Projectiles, when Parabolas, is very briefly and elegantly handled by Mr. *Cotes*, at the End of his Works. So it is also in the *French* Memoirs of the Royal Academy at *Paris*, for the Year 1731, or thereabouts.

PROJECTION *of the Sphere* in plano, is a true geometrical Delineation of the Circles of the Sphere, or any assigned Parts of them, upon the Plane of some one Circle; as on the Horizon, Meridian, Equator, Tropic, *&c.*

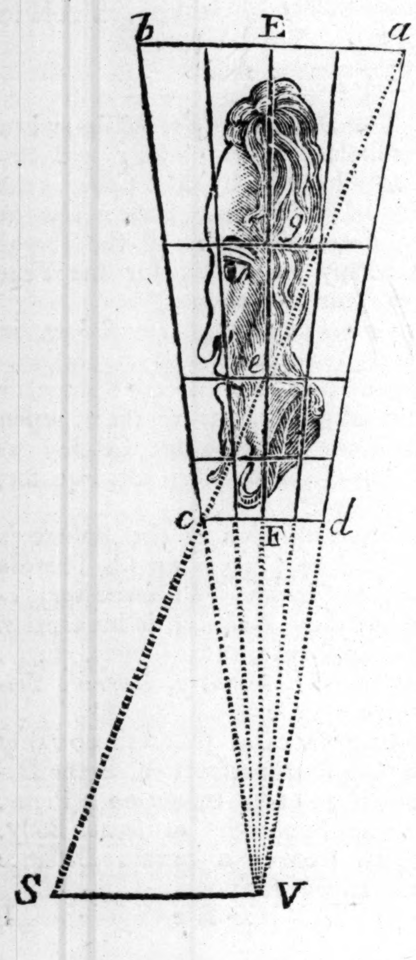
The Projection of the Sphere is handled by *Clavius*, in his Treatise of the *Astrolabe*. Likewise very elegantly by *Agulonius*, in his Optics. See also *Taquet*, in his Optics, *Witty*, *Haines*'s *Trigonometry*, *Harris*'s *Trigonometry*, *&c.*

PROJECTION (MONSTROUS) *of an Image*, in perspective, is the Deformation of an Image on a Plane, or the Superficies of some Body, which seen at a certain Distance will appear formous.

If it be required to delineate a monſtrous Projection on a Plane, proceed thus:

1. Make a Square ABCD (called the *Craticular Prototype*) of a Big-

neſs at pleaſure, and divide the Side AB into a Number of equal Parts, that ſo the ſaid Square may be divided into a Number of Areola's, or leſſer Squares.



2. In this Square let the Image, to be repreſented deformed, be drawn.

3. Draw the Line $ab = AB$, and divide it into the ſame Number of equal Parts, as the Side of the *Prototype* AB is divided into.

4. In E, the middle thereof, erect the Perpendicular EV, ſo much the longer, as the Deformation of the Image is to be greater.

5. Draw VS perpendicular to EV, ſo much the leſs in Length, as you would have the Image appear more deformed.

6. From each Point of Diviſion draw ſtraight Lines to V, and join the Points *a* and S, as alſo the Right Line *a*S.

7. Thro' the Points *d, e, f, g*, draw Right Lines parallel to *ab*. Then will *abcd*, be the Space that the *monſtrous Projection* is to be delineated in, called the *Craticular Ectype*.

8. In every Areola, or ſmall Trapezium of this Space *abcd*; let there be drawn what appear delineated in the correſpondent Areola of the Square ABCD, and by this means you will obtain a deform'd Image, which will appear formous to an Eye diſtant from it by the Length FV, and raiſed above it the Height VS.

9. It will be very diverting to manage it ſo, that the deformed Image does not repreſent a mere Chaos; but ſome other Image different from it, which by this contrivance ſhall be deformed. As I have ſeen a River with Soldiers, Waggons, &c. marching along the ſide of it, ſo drawn, that when it is looked at by an Eye in the Point S, appears to be the ſatyrical Face of a Man.

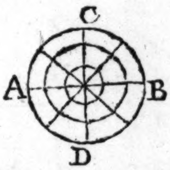
10. An Image may be deformed mechanically, if you place the Image, having

having little Holes here and there made in it with a Needle or Pin, against a Candle or Lamp, and observe where the Rays going thro' these little Holes fall on a Plane, or Curve-Superficies; for they will give the correspondent Points of the Image deformed, by which means the Deformation may be compleated.

To draw the Deformation of an Image upon the Convex-Surface of a Cone.

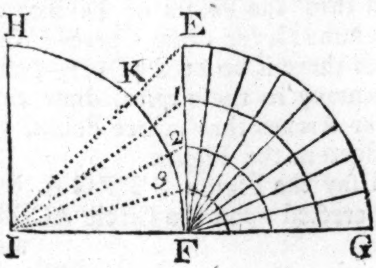
From the last Problem it is manifest enough, that all that is to be done here is to make the *Craticular Ectype* in the Superficies of the Cone, which shall appear to an Eye duly placed over the Vertex of it, equal to the *Craticular Prototype*. Therefore,

1. Let the Base A B C D of the Cone, (*Fig.* 1.) be divided by Diameters into any Number of equal Parts; that is, let the Periphery be thus divided.



2. Likewise let some one Radius be divided into equal Parts, and thro' each Point of Division draw concentric Circles. And thus shall the *Craticular Prototype* be made.

3. With the double of the Diameter A B, as a Radius, describe the Quadrant EFG, (*Fig.* 2.) so that the Arch E G may be equal to the whole Periphery; then this Quadrant folded rightly up, will form the Superficies of a Cone, whose Base is the Circle A B C D.



4. Divide the Arch E G into the same Number of equal Parts, as the *Craticular Prototype* is divided into, and draw Radii from each of the Points of Division.

5. Produce G F to I, so that F I = F G, and from the Centre I, with the Radius I F, draw the Quadrant F K H, and from I to E draw the Right Line I E.

6. Divide the Arch K F into the same Number of equal Parts, as the Radius of the *Craticular Prototype* is divided into, and draw Radii thro' each of the Points of Division from the Centre I, meeting E F in 1, 2, 3, *&c.*

7. Finally, from the Centre F with the Radii, F1, F2, F3, *&c.* describe concentric Arches. Thus will you have the *Craticular Ectype*, whereof each Areola will appear equal to one another.

8. Therefore, if what is delineated in every Areola of the *Craticular Prototype* be transferred into the Areola's of the *Craticular Ectype*, the Image will be deformed; but the Eye being duly raised over the Vertex of the Cone, will perceive it formous.

9. If the Chords of the Quadrants be drawn into the *Craticular Prototype*, and Chords of their fourth Part in the *Craticular Ectype*, all things else remaining the same; you will have the *Craticular Ectype* in a quadrangular Pyramid. And from hence you may learn how to deform an Image in any other Pyramid, whose Base is any regular Polygon.

10. Because the Eye will be more deceived, if from contiguous Objects it cannot judge of the Distance of the Parts of the deformed Image: Therefore, these kind of deformed Images must be looked at thro' a small Hole.

To delineate a Figure in an horizontal Plane, which shall appear by Reflexion on a Cylindrical Speculum standing on that Plane, like a Square divided into many little square Areola's.

1. About EB (*Fig.* 2.) the Diameter of the Cylindrical Speculum, describe a Circle equal to the Base of the Cylinder.

2. Take the Point O under the Eye, and draw the Tangents OE, OB; because no Ray reflected from the Speculum beyond them, will fall upon the Eye. Likewise the Right Lines OB, OE, may be so drawn,

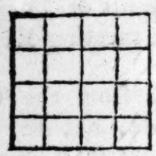


Fig. 1.

as to cut the Circle; since what are perceived by the Tangents, will not be distinct enough.

3. Join the Points of Contact, or Intersection E,B, by a straight Line EB, which must be taken for the Side of the Square appearing in the Speculum: Because the Image appears in a Cylindrical Speculum between the Centre and the Superficies.

4. Divide EB into any Number of equal Parts; and from every of the Points of Division, 1, 2, 3, &c. draw Right Lines O1, O2, O3, &c. to the Point O under the Eye.

5. Let the Radii OH, OI, be reflected to the Points F,G, &c. that is, let HF, IG, be the Reflexions of O1, O2, &c.

6. Upon the indefinite Right Line MQ, (*Fig.* 3.) raise the Perpendicular MP, equal in Length to the Height of the Eye.

7. From M to Q transfer the Line OH, and at Q raise the Perpendicular QR, which let be equal

PRO

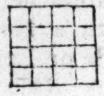
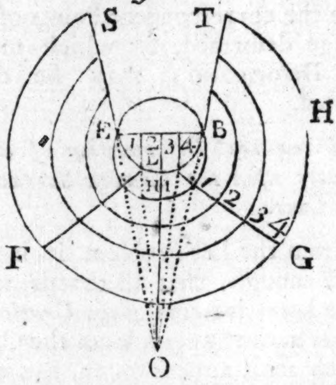


Fig 2



to the Side of the Square appearing in the Speculum, and divide the

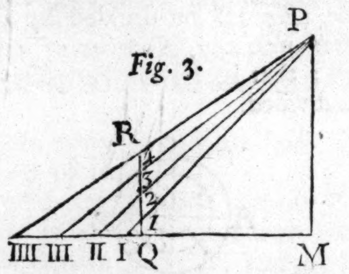


Fig. 3.

same into the same Number of equal Parts, as that Side is divided into.

8. Thro' every Point of Division 1, 2, 3, &c. draw the Right Lines P.I, P.II, P.III, &c.

9. From L to 1, 2, 3, &c. transfer the Right Lines L1, L2, L3, &c. equal to QI, QII, QIII, &c.

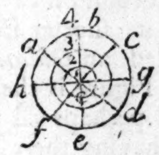
10. After the same manner, let the Lines HF, IG, &c. be divided; and thro' the Points of Division of the same Order draw Curves: Or, since there is no need of very great Accuracy in these cases, draw circular Arches thro' three Points, as is done in the Figure.

I say the Figure STFGA, being erected upon the Circle ACDB, will

will appear in the Cylindrical Speculum, as a Square divided into several equal square Areola's. Whence, if a Square be made, whose Side is equal to QR, and the same be divided into equal Areola's, and in the same be painted any Image, and then what is in every Areola of it be transferred in the correspondent Areola's of the deformed Square, that deformed Image will by Reflexion appear formous in the Cylindrical Speculum.

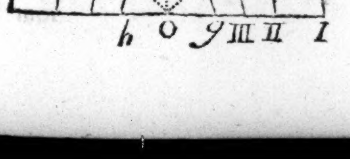
To delineate a deformed Figure upon an horizontal Plane, that shall appear formous by the Reflexion of a Conical Speculum to an Eye over the Vertex.

1. The Image to be deformed must be delineated in a Circle, equal to the Base of the Conical Speculum, and the Periphery must be



divided into equal Parts by the Diameters, *ad*, *be*, *cf*, &c. and the Radii O*b*, O*c*, O*d*, &c. (*Fig.* 1.) into equal Parts O*a*, 1.2, 2.3, &c. by Concentric Circles.

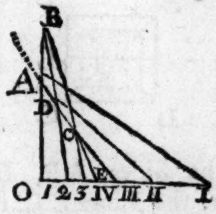
2. To get the Points I, II, III, &c. in the Plane that the Cone's Base stands upon, which are seen by reflected Rays within the Speculum at the Points, 1, 2, 3, &c. make (*Fig.* 2) a right-angled Triangle, AOE, whose Base OE is equal to the Radius of the Speculum, and Altitude AO equal to the Height of the Speculum, that is equal to



its Axis. And in AO produced take AB equal to the Height of the Eye.

3. To every of the Points 1, 2, 3, &c. of Division from the Point B, wherein the Eye is supposed, draw the Right Lines, B1, B2, B3, &c.

Fig. 2.



4. Because these are the reflected Rays by which the Points 1, 2, 3, &c. are seen, and AE is the Intersection of the Plane of Reflexion and the Speculum, make the Angles IDE, II, CE, equal to the Angles BDA, BCA, &c. then shall D.I, C.II, &c. be the Rays of Incidence: Consequently I. II, &c. the radiating Points which are seen by Reflexion, in 1, 2, 3, &c.

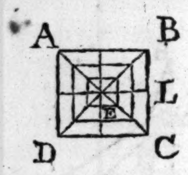
5. Therefore produce the Radii O*a*, O*b*, O*c*, &c. in the *Craticular Prototype*, and transfer in them the Divisions O.I, O.II, O.III, &c. And lastly draw Concentric Circles from the Point O, and thus will you have the *Craticular Ectype*.

6. Therefore if in every of its Areola's you depict what you find in the correspondent Areola's of the *Craticular Prototype*, you will have a deformed Figure, which will appear formous by Reflexion to an Eye duly placed over the Vertex of the Cone.

To delineate a deformed Image upon a Plane, that shall appear formous by Reflexion to an Eye, placed over the Vertex of a Pyramidal Speculum.

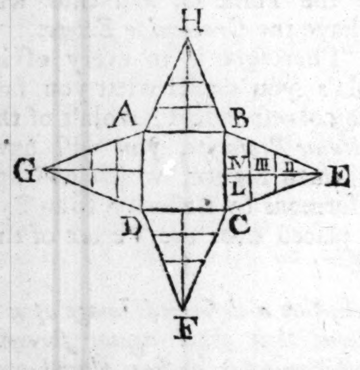
For Example. Let it be required to delineate a deformed Image, which will appear formous by the Reflexion of a quadrangular Pyramid.

1. In this case, the Image to be deformed, is to be delineated into the Square ABCD, equal to the Base of the Speculum, whose Perimeter must be divided into equal Parts by Diagonals, from the Centre E; and also by Right Lines, bis-



secting the Sides AB, BC, *&c.* Moreover, the Lines EL, EB, must be divided into any Number of equal Parts; so that Lines drawn thro' the Points of Division, which are parallel to the Sides of the Base, may include the *Craticular Prototype.*

2. Now, since the Section of the Speculum thro' the Axis, and the Right Line EL drawn in the Base, is a right-angled Triangle; and every Point of Division of the *Craticular Prototype,* is in the reflexed Ray, after the very same manner as in the last Problem are found the Points I, II, III, *&c.* of the Axis LE, of the Triangle BEC,



to be reflected: Which being given, the Triangle itself may be made.

3. *Lastly,* What else is to be done, must be proceeded with, as in the last Problem.

Note, Deformed Images, that are made by means of pyramidal Speculums, are more diverting than those made by others. Because the Parts of the deformed Image being disjoined, any others may be painted between them, forming one and the same continuous thing with them without the Speculum, which in the Speculum will not be seen.

PROJECTURE, in Architecture, signifies the Prominency or Embossment, which the Mouldings, and other Members have, beyond the naked Wall; and is always in proportion to its Height. The word is also applied to Galleries, Balconies, *&c.* which jet beyond the Face of the Wall.

PROLATE SPHEROID, is a Solid produced by the Revolution of a Semi-Ellipsis about its longer Diameter or Axis; but if a Solid be formed by the Revolution of a Semi-Ellipsis about its shorter Diameter, it is then called an *Oblate Spheroid:* And of this Figure is the Earth we inhabit, and perhaps all the Planets are so too, having their Equatorial Diameters longer than their Polar.

PROMONTORY, is an Hill or high Land running out into the Sea, the Extremity of which towards the Sea, is usually called a *Cape,* or *Headland.*

PROPORTION, is an Equality of Ratio's.

1. *Magnitudes* are said to have Proportion to each other, which being multiplied can exceed one another.

2. *Magnitudes* are said to be in the same Ratio, the first to the second, and the third to the fourth, when the Equimultiples of the first and third, compared with the Equimultiples of the second and fourth, according to any Multiplication whatsoever, are either both together greater, equal, or less, than the Equimultiples of the second and

fourth,

fourth, if those be taken that answer each other.

That is, if there be four Magnitudes, and you take any Equimultiples of the first and third, and also any Equimultiples of the second and fourth: And if the Multiple of the first be greater than the Multiple of the second, and also the Multiple of the third greater than the Multiple of the fourth: Or, if the Multiple of the first be equal to the Multiple of the second; and also the Multiple of the third equal to the Multiple of the fourth: Or, lastly, if the Multiple of the first be less than the Multiple of the second; and also that of the third less than that of the fourth; and these things happen according to every Multiplication whatsoever; then the four Magnitudes are in the same Ratio, the first to the second, as the third to the fourth.

Expounders usually lay down here that Definition which *Euclid* has given for Numbers only, in his seventh Book, *viz.* That

Magnitudes are said to be Proportionals, when the first is the same Equimultiple of the second, as the third is of the fourth, or the same Part or Parts.

But this Definition appertains only to Numbers and commensurable Quantities; and so since it is not universal, *Euclid* did well to reject it in his 5th Element, which treats of the Properties of all Proportionals; and to substitute another general one, agreeing to all kinds of Magnitudes. In the mean time, Expounders very much endeavour to demonstrate the Definition here laid down by *Euclid*, by the usual received Definition of Proportional Numbers; but this much easier flows from that, than that from this.

1. If there are four Quantities proportional, as a, ea, b, eb, then they will be also proportional.

1. *Inversly*, $ea : a :: eb : b$.
2. *Alternately*, $a : b :: ea : eb$.
3. *Compoundedly*,
$a+ea : ea :: b+eb : eb$.
4. *Conversly*, $a+ea : a :: b+eb : b$.
5. *Dividedly*,
$a-ea : \begin{cases} ea \\ a \end{cases} :: b-eb \begin{cases} : eb. \\ : b. \end{cases}$
6. By a *Syllepsis*,
$a : ea :: a+b : ea+eb$.
7. By a *Dialepsis*,
$a : ea :: a-b : ea-eb$.

2. If in two Rows of Proportionals $a : ea :: b : eb$, and $ea : oa :: eb : ob$; then *by ordinate Proportion of Equality*, $a : oa :: b : ob$. But if they are disorderly placed, *viz.* $oa : ea :: ob : eb$; and $ea : a :: eob : ob$: then $oa : a :: eob : eb$. If there are two Rows of Proportionals $a : ea :: b : eb :: c : oc :: d : od$: then shall $a \times c : ea \times oc :: b \times d : eb \times od$. All these are manifest by comparing the Rectangles of the Means and Extremes, or by dividing the Consequents by their Antecedents.

PROPORTIONAL SCALES, sometimes also called *Logarithmetical*, are only the artificial Numbers or Logarithms placed on Lines, for the Ease and Advantage of multiplying, dividing, extracting Roots, &c. by the means of Compasses, or by Numbers, as they are called by Mr. *Gunter*; but made single, double, triple, or quadruple; beyond which they seldom go.

PROPORTIONAL *Spiral Lines*. See *Spiral Lines*.

PROSTAPHERESIS, in Astronomy, is the same with the Equation of the Orbit, or simply the Equation; and is the Difference between the true and mean Motion of a Planet. The Angle also made by the Lines of the Planets mean and true Motion, is called the *Prostapheresis*.

PROTRACTING-PIN, is a fine Needle fastned in a Piece of Wood, Ivory, &c. used to prick off any Degrees and Minutes from the Protractor.

Protractor, is an Inſtrument uſed in Surveying: It is commonly made of a well-poliſhed thin Piece of Braſs, and conſiſteth of a Semi-Circle divided into Degrees, and a Parallelogram with Scales upon it, and may be of any bigneſs deſired.

Its Uſe is chiefly to lay down an Angle of any aſſigned Quantity of Degrees: Or, an Angle being protracted, to find the Quantity of Degrees it contains readily; which is of great uſe in plotting, and making of Draughts, *&c.*

Pseudostella, in Aſtronomy, ſignifies any kind of Comet or Phænomenon newly appearing in the Heavens like a Star.

Ptolemaic *Syſtem of the Heavens*, was that invented by *Ptolemy*; in which he ſuppoſes the Earth immoveable any way in the Centre of the Univerſe, round about which the Moon firſt moves in a Circle; next her *Mercury*, then *Venus*: Above which moves the *Sun*, then *Mars*; above him *Jupiter*, and laſt of all *Saturn*, all in the Zodiac from Weſt to Eaſt. Above *Saturn* he places the Sphere of the fixed Stars, which he ſuppoſes to move ſlowly alſo, from Eaſt to Weſt, on the Poles of the Ecliptic. While the fixed Stars themſelves, and all the Planets, move from Eaſt to Weſt on the Poles of the Equator, in the Space of a natural Day or twenty-four Hours. This vulgar Syſtem of Aſtronomy, (in which I omit to mention the Epicycles and Deferents, *&c.* with which they endeavoured to ſolve the Phænomena which did almoſt all of them contradict this Scheme) was plainly overturned and refuted as ſoon as ever the Uſe of the Teleſcope acquainted us with the Phaſes of *Venus* and *Mercury*; for from thence it was apparent, that their Orbits included the Sun, and therefore by degrees it came to be quite diſuſed.

Pulley, is a little Wheel moveable about its Axis, over which goes a Drawing-Rope.

1. In ſeveral caſes where the Axis in Peritrochio cannot conveniently be applied, Pulleys muſt be made uſe of to raiſe Weights: A Machine made by combining ſeveral of them, lies in a little compaſs, and is eaſily carried about, if the Weight be fixed to the Pulley, ſo that it may be drawn up along with it: Each End of the Drawing or Running-Rope ſuſtains half the Weight; therefore when one End is fixed, either to a Hook, or any other way, the moving Force or Power applied to the other End, if it be equal to half the Weight, will keep the Weight *in Æquilibrio.*

2. Several Sheaves may be joined in any manner, and the Weight be fixed to them; then if one End of the Rope be fixed, and the Rope goes round all thoſe Sheaves, and as many other fixed ones, as is neceſſary, a great Weight may be raiſed by a ſmall Power: In that caſe, the greater the Number of Sheaves fixed in a moveable Pulley, or of moveable Wheels are (for the fixed ones do not change the Action of the Power,) ſo much may the Power be leſs, which ſuſtains the Weight; and a Power which is to the Weight, as the Number one to twice the Number of the Sheaves, will ſuſtain the Weight.

Pulse, by the Mathematical Naturaliſts, is the Term uſed for that Stroke with which any Medium is affected by the Motion of Light, Sound, *&c.*

And Sir *Iſaac Newton* demonſtrates, *Lib.* 2. *Prop.* 48. *Princip.* that the Velocities of the Pulſes, in any elaſtic fluid Medium, (whoſe Elaſticity is proportionable to its Denſity,) are in a Ratio, compounded

ed of the ſubduplicate Ratio of the Elaſtic Force directly, and the ſubduplicate Ratio of the Denſity inverſly. So that in a Medium, whoſe Elaſticity is equal to its Denſity, all Pulſes will be equally ſwift.

Pulsion, is the driving or impelling of any thing forward.

Punchins, in Architecture, are ſhort Pieces of Timber placed to ſupport ſome conſiderable Weight: They commonly ſtand upright between the Poſts, and are ſhorter and ſlighter than either the principal Poſts or Prick-poſts. Thoſe that ſtand on each ſide of a Door are called *Door-Punchins*.

Punctated Hyperbola, is any Hyperbola whoſe Conjugate Oval is infinitely ſmall, that is, a Point.

Punctum Formatum *ſeu* Generatum, in Conics, is a Point determined by the Interſection of a Right Line drawn thro' the Vertex of a Cone to a Point in the Plane of the Baſe, with the Plane that conſtitutes the Conic Section. See *De la Hire*'s Latin Conics, *p.* 15, 16.

Punctum ex Comparatione, is either Focus, in an Ellipſis and Hyperbola; and it was ſo called by *Apollonius*, becauſe the Rectangles under the Segment of the Tranſverſe Diameter in the Ellipſis, and under that and the Diſtance between the Vertex and Focus in the Hyperbola, are equal to $\frac{1}{4}$ Part of what he calls the Figure.

Punctum Lineans, is that Point of the generating Circle, which in the Formation of either ſimple Cycloids or Epicycloids, produces any Part of a Cycloidal Line.

Pure Hyperbola, is one, which, by the Impoſſibility of its Roots, is without any Oval, Node, Spike, or Conjugate Point.

Purlines, in Architecture, are thoſe Pieces of Timber, which lie a-croſs the Rafters on the Inſide, to keep them from ſinking in the middle of their Length.

Pyramid, in Geometry, is a ſolid Figure, whoſe Baſe is a Polygon, and whoſe Sides are plain Triangles, their ſeveral tops meeting together in one Point.

1. The Solidity of a Pyramid is $\frac{1}{3}$ of the perpendicular Altitude multiplied by the Baſe.

2. The ſuperficial Area of a Pyramid is found by adding the Area of all the Triangles, whereof the Sides of the Pyramid conſiſt, into one Sum.

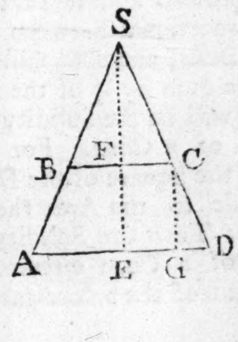
3. The external Surface of a right Pyramid, that ſtands on a regular Polygon-Baſe, is equal to the Altitude of one of the Triangles which compoſe it, multiplied by the whole Circumference of the Baſe of the Pyramid.

The Demonſtrations of the three following Problems being ſhort and eaſy, and not every where to be found; I therefore thought it might not be amiſs to inſert them here.

1. *To find the Solidity of the Fruſtum of a ſquare Pyramid.*

Let A D be one of the Sides of the greater Baſe, which let us call *b*, and B C the Side of the leſſer Baſe, which call *a*; and let E F be the Height of the Fruſtum, which let be *h*.

Now, compleat the whole Pyramid A S D, and draw the Line G G,



parallel

parallel to EF. Now, because the Triangles ADS, BCS, are similar, it will be as $b-a$: (2GD) b :: (EF = GC) b : (AD) : $\frac{bb}{b-a}$ (ES). And in like manner, as $b-a$: (2GD) b :: (EF=GC) a : (BC) : $\frac{ab}{b-a}$ (FS). Therefore the Solidity of the Pyramid ASD, will be $\frac{hb^3}{3b-3a}$. And the Solidity of the Pyramid BSC, will be $\frac{ha^3}{3b-3a}$, and consequently the Solidity of the Frustum ABCD of the Pyramid, will be $\frac{hb^3-ha^3}{3b-3a}$; and by dividing $3b-3a$) hb^3-ha^3 ($\frac{hbb}{3}+\frac{haa}{3}+\frac{hab}{3}$. This last Expression will be the Solidity of the Frustum; therefore, if the Sum of the Bases, and the Rectangle under the Sides AD and BC, are added together, and multiplied by $\frac{1}{3}$ of the Height EF, the Product will be the Solidity of the Frustum.

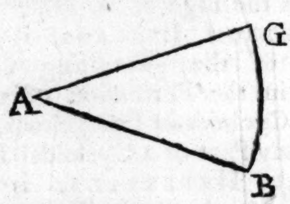
COROLLARY.

Hence the Solidity of the Frustum of a Cone, or any other kind of Pyramid, may be also found. For it is but adding the two circular Bases together, and to that Sum a mean Proportional between the said circular Bases, and then multiplying the whole Sum by $\frac{1}{3}$ of the Height, and that will be the Solidity of the Frustum of a Cone. For let the Ratio of the Square of the Diameter of a Circle to the Area thereof be as r to s: Then the Solidity of the Frustum of a Cone circumscribing the Frustum of the before-mentioned square Pyramid, will be $\frac{h}{3}\times\frac{sbb}{r}+\frac{saa}{r}+\frac{sba}{r}$. Whence it is manifest, that $\frac{sbb}{r}$, and $\frac{saa}{r}$ is the Sum of the circular Bases, and $\frac{sba}{r}$ a mean Proportional between the circular Bases. Therefore the *Corollary* is manifest.

2. *To find the Curve-Superficies of a right Cone.*

If a right Cone ABD lies upon the Plane AC, or touches it in the Right Line AB; and if the said Cone revolves upon the said Plane about the Point A, until the Point

B, in the Periphery of the Base, comes to touch the Plane again. Then, I say, that the whole Superficies of the Cone will have touched the Plane in every Part; and consequently, if the Lines AB, AG, be equal to AB, the slant Height of the Cone, and about the Centre A, be described an Arch of a Circle, whose Length BG is equal to the Periphery of the circular Base

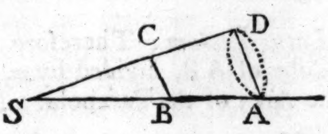


of the Cone, that the Area of the circular Sector ABG will be equal to the Curve Superficies of the Cone. Therefore, if half the Periphery of the Base of any Right Cone be multiplied

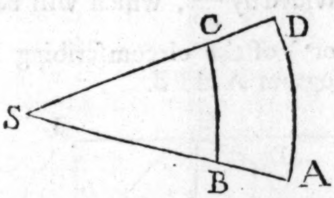
tiplied by the slant Height, you will have the Area of the Curve-Surface thereof.

3. *To find the Area of the Curve-Surface of the Frustum of a Right Cone.*

Let us call the slant Height A B, a; the Diameter A D of one of the Bases c, and the Diameter of



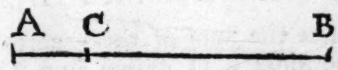
the other Base B C, b. Also let us call the Periphery of the greater Base p, and of the lesser q. Now, if S B, S A, are equal to S B, S A, and about the Point S be described



two Concentric Portions of Circles, the greater of which is equal to the Periphery of the greater Circular Base D A, then the Area C D A B will be equal to the Area of the Curve Superficies of the Frustum sought. Now to get this Area we must find S A, and S B, the former will be $\frac{ac}{c-b}$, and the other $\frac{ab}{c-b}$, whence the Area of the Sector S A D, will be $\frac{pac}{2c-2b}$, and the Area of the other lesser Sector SCB, will be $\frac{qab}{2c-2b}$. And therefore the Area of the Figure C D A B, that is the Area of the Superficies of the Frustum will be $\frac{pac-qab}{2c-2b}$. That is, $\frac{a}{2} \times \overline{\frac{pc-qb}{c-b}}$. Now let us suppose n to be such a Quantity, that if the Periphery of a Circle be divided by it, the Quotient will be the Diameter. This being supposed, $\frac{p}{n} =$ c, and $\frac{q}{n} = b$. Then our last Theorem will be thus, $\frac{pp-qq}{p-q}$, multiplied by $\frac{a}{2}$ will be the Area of the Superficies of the Frustum; but $pp-qq$ divided by $p-q$, will be $p+q$. Therefore, to find the Curve-Superficies of the Frustum of any Cone, you must add the Circumferences of the two Bases together, and that Sum multiplied by $\frac{1}{2}$ of the slant Height, will be the Area of the Curve-Superficies sought.

Having happened upon a very easy way of squaring the Parabola, by the Method of Indivisibles, I thought it would not be amiss to insert it here. But first the following Lemma must be demonstrated.

The Sum of all the Rectangles (infinite in Number) that can be made by cutting the given Line A B *into two Segments, as* A C × C B, *is equal to* $\frac{1}{6}$ *of the Cube of the said Line.*



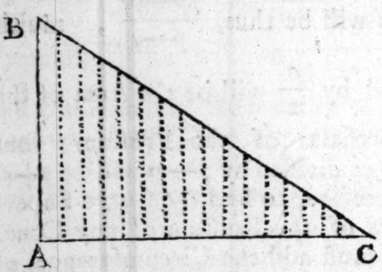
DEMONSTRATION.

Let us call the whole Line a, the Segment AC, x, then $\overline{a-x} \times x$ will be the first Rectangle, $\overline{a-2x} \times 2x$ the second, $\overline{a-3x} \times 3x$ the third, and

and $\overline{a-4x} \times 4x$, the fourth, and so on. That is, the Sum of the Rectangles will stand thus,

$a \times 1x - 1xx$
$a \times 2x - 4xx$
$a \times 3x - 9xx$
$a \times 4x - 16xx$, &c.

From whence you may see that the Sum of all the first Terms will be equal to the Solidity of a triangular Prism whose Height is a, and the Base the Right-angled Isosceles Triangle CAB, each of whose equal

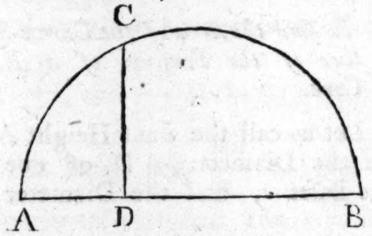


Sides is $=a$. Therefore their Sum is $\frac{a^3}{2}$. Again, the Sum of all the second Terms, (because the Co-efficients are the Squares of Numbers in Arithmetical Progression,) will be equal to a square Pyramid, having its Base doubled to B A C, and the same Altitude a, whence their Sum will be $\frac{a^3}{3}$. And taking $\frac{a^3}{3}$ from $\frac{a^3}{2}$, you will have $\frac{1}{6}\,aaa$ for the Sum of all the Rectangles. Q. E. D.

COROLLARY I.

Hence the Sum of the Squares of all the Sines CD drawn in a Circle, is equal to $\frac{1}{6}$ of the Cube of the Diameter. And so the Solid called the *Hoof* or *Ungula*, may be squared.

Likewise from hence we may have the Quadrature of the *Apollonian* Parabola (See *Fig.* 2.) For because the Rectangle under $AC \times CB$, is equal to DC multiplied into some standing Quantity, as m, which is



the *Latus Rectum*: Therefore $\frac{1}{6}$ of the Cube of A B, divided by m, will be the Area of the Parabola. Now $m = \frac{aa}{4}$ divided by GF, which suppose b, that is, $\frac{aa}{4b} = m$. Therefore the Area of the Parabola will be $\frac{a^3}{6}$ divided by $\frac{aa}{46}$, which will be $\frac{4}{6}$ $b\,a$, or $\frac{2}{3}$ of the circumscribing Parallelogram A H I B.

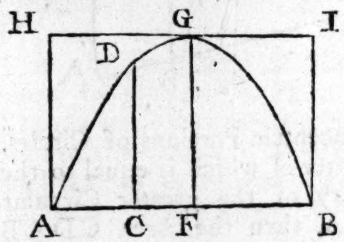


Fig. 2.

PYRAMIDOID, is what is sometimes called a *Parabolic Spindle*; and is a solid Figure formed by the Revolution of a Parabola round its Base or greatest Ordinate.

PYTHAGOREAN THEOREM, is the 47th Prop. of the first Book of *Euclid*.

PYTHAGOREAN SYSTEM, is the same with the *Copernican*, but is so called, as being maintained by *Pythagoras*, and his Followers, and is the most ancient of any. In this the Sun is supposed at Rest in the Centre of our System of Planets, and the Earth to be carried

ried round him annually in a Track or Path between *Venus* and *Mars*.

Q.

QUADRANGLE, or *Quadrangular Figure* in Geometry, is that which hath four Angles.

QUADRANT, is an Arch which is the fourth Parth of a Circle, containing 90 Degrees. And oftentimes the Space contained between a quadrantal Arch, and two Radii perpendicular one to another in the Centre of a Circle, is called a *Quadrant*.

QUADRANT *of Altitude*, is a Part of the Furniture of an artificial Globe, being a thin Brass-Plate divided into 90 Degrees, and marked upwards with 10, 20, 30, *&c.* being rivetted to a Brass Nut which is fitted to the Meridian, and hath a Screw in it, to screw upon any Degree of the Meridian: When it is used, 'tis most commonly screwed to the Zenith. Its Use is for measuring of Altitudes, to find Amplitudes and Azimuths, and describing Almicanters.

QUADRANT ASTRONOMICAL. See *Astronomical Quadrant*.

QUADRANT TRIANGLE. See *Triangular Quadrant*.

QUADRANTAL TRIANGLE, is a Spheric Triangle, one of whose Sides, (at least,) is a Quadrant, and one Angle Right.

QUADRAT, *or* LINE *of* SHADOWS *on a Quadrant*, are only a Line of natural Tangents to the Arches of the Limb, and are placed there in order to measure Altitudes readily; for it will always be, As Radius to the Tangent of the Angle of Altitude at the Place of Observation; (that is, to the Parts of the Quadrats or Shadows cut by the String:) So is the Distance between the Station and Foot of the Object to its Height above the Eye.

QUADRATIC *Equation*, is one, when made as simple as possible, that consists of not more than three Terms; the third of which is a known Number or Quantity, and the Dimension or Power of the unknown Quantity making the first Term is the double of the unknown Quantity (or its Power) constituting the second Term.

All Quadratic Equations consist of one of the following Forms:

$$1.\ xx \pm a = o.$$
$$2.\ xx \pm ax = o.$$
$$3.\ xx \pm ax \pm b = o.$$

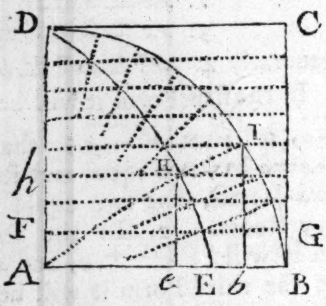
Or generally 4. $x^{2m} \pm ax^m \pm b = o$.

1. In the first Form it will be $x = \sqrt{+a}$, or $x = \sqrt{-a}$; that is, $xx - a = o$ has two equal real Roots, and $xx + a = o$, has two equal imaginary Roots. 2. In the second Form it will be $x = \pm a$, and $x = o$. 3. In the third Form it will be $x = \left\{\begin{matrix} -\frac{1}{2} - \sqrt{\frac{1}{4}aa - b} \\ -\frac{1}{2} - \sqrt{\frac{1}{4}aa - b} \end{matrix}\right.$, that is when it is $xx + ax + b = o$, the two Roots or Values of x will be negative. But when it is $xx + ax - b = o$, the two Roots or Values of x will be the one affirmative, and the other negative; that is, it will be $x = \left\{\begin{matrix} \frac{1}{2}a + \sqrt{\frac{1}{4}aa + b} \\ \frac{1}{2}a - \sqrt{\frac{1}{4}aa + b} \end{matrix}\right.$. When it is $xx - ax + b = o$, then will $x = \left\{\begin{matrix} \frac{1}{2}a + \sqrt{\frac{1}{4}aa + b} \\ \frac{1}{2}a - \sqrt{\frac{1}{4}aa + b} \end{matrix}\right.$, the two Values of x being both affirmative. When it is $xx - ax - b = o$, then will $x = \left\{\begin{matrix} \frac{1}{2}a + \sqrt{\frac{1}{4}aa + b} \\ \frac{1}{2}a - \sqrt{\frac{1}{4}aa + b} \end{matrix}\right.$, one Root or Value of x being the one affirmative, and the other negative. 4. Lastly,

Lastly, in the fourth Form it will be $x = \sqrt{\pm \frac{1}{2}a \pm \sqrt{\frac{1}{4}aa \pm b}}$.

If the last Term of a Quadratic Equation be negative, its two Roots will be real; and when the last Term is affirmative, and $\frac{1}{4}$ the Square of the Co-efficient of the second Term be less than the third Term, the two Roots will be imaginary.

QUADRATRIX, (in Geometry,) is a Curve-Line thus generated. Let there be a Radius of a Circle, as AD, which imagine to move on the Centre A down the Circumference of the Quadrant DB, and at the same time let the Side of the Square CD move equally downwards, so that the Radius AD, and the Side of the Square CD may come to the Line AB together. Or let the Right Line DA, and the Quadrantal Arch DB, be both divided into a like Number of equal Parts, as in this case, they are each into 8, and to the Divisions of the Quadrant, let as many Radii be drawn from the Centre A, and thro' the Divisions in AD as many Parallels to CD; for then if a Curve-Line be drawn neatly connecting the Points of Intersection of these Radii and Parallels, it will be that Line which is called the *Quadratrix*, (as DE.)



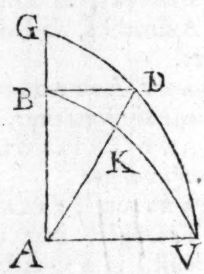
1. If through any Point, as H in this Quadrartix, you draw a Radius AHI, and the two Perpendiculars H*h* and H*e*, it will be, As the whole Quadrantal Arch DB is to the Part IB: So will the whole Right Line DA be to the Part of it cut off *b*A, or its Equal H*e*.

2. Wherefore any Arch of the Quadrant as IB, or any Angle as IAB, may by this Quadratrix be easily divided into three equal Parts, or any other Number at pleasure, or according to any given Ratio, by only drawing the Radius AI, and then from the Point of the Quadratrix H, letting fall the Perpendicular H*e*.

3. The Base of the Quadratrix AE, is a third Proportional to the Radius AD, and the Quadrant BD.

4. If on the Base of the Quadratrix AE, a Quadrantal Arch be described, it will be equal in Length to DA, the Side of the Square: And consequently the Semi-Circle will be double; and the Periphery Quadruple of DA.

5. If AV the Base of a Circle inscribed in the Quadratrix, GV be 1, and the Arch of the Circle VK be called x, then will the Area BDVA $= x - \frac{1}{9}x^3 - \frac{1}{225}x^5 - \frac{2}{6615}x^7 -$, &c.



QUADRATURE *of any Figure in the Mathematics*, is the finding a Square equal to the Area of it.

This Doctrine is as far advanced by Sir *Isaac Newton* in his Quadrature of Curves, published by Mr. *Jones*,

Jones, as the Nature of the thing will admit with any Elegance and Perſpecuity; nor is every Man capable, altho' perhaps a tolerable Mathematician, of perceiving the Progreſs this great Man has made in this difficult Part of the Science.

QUADRATURES *of the Moon*, are the middle Parts of her Orbit, between the Points of Conjunction and Oppoſition: And they are ſo called, becauſe a Line drawn from the Earth to the Moon, is then at Right Angles, with one drawn from the Earth to the Sun.

QUADRILATERAL FIGURES, are thoſe whoſe Sides are four Right Lines, and thoſe making four Angles; and they are either a Parallelogram, Trapezium, Rectangle, Square, Rhomboides, or Rhumbus.

QUADRIPARTITION, is to divide by four, or to take the fourth Part of any Number or Quantity.

QUALITY, ſignifies in the general the Properties or Affections of any Being, whereby it affects our Senſes ſo and ſo, and acquires ſuch and ſuch a Demonſtration.

1. *Senſible Qualities*, are ſuch as are the more immediate Objects of our Senſes.

3. *Occult Qualities*, were by the Ancients named ſuch, of which no rational Solution in their way, or according to their Principles, could be given.

QUANTITY, ſignifies whatſoever is capable of any ſort of Eſtimation or Menſuration, and which being compared with another thing of the ſame nature, may be ſaid to be greater or leſs, equal or unequal to it.

1. The Quantity of Matter in any Body, is its Meaſure ariſing from the joint Conſideration of its Magnitude and Denſity.

2. The Quantity of Motion in any Body, is its Meaſure ariſing from the joint Conſideration of the Quantity of Matter in, and the Velocity of the Motion in that Body.

QUARTERS, *in a Clock, or Movement*, are little Bells which ſound the Quarters, or other Parts of an Hour.

QUARTILE, is an Aſpect of the Planets, when they are 3 Sines or 90 Degrees diſtant from each other, and is marked thus □.

QUAVER, is a Note in Muſic ſo called. See the Words *Notes* and *Time.*

QUEUE D'ARONDE, a Term in Fortification, being what we call *Swallow's Tail*; and ſignifies a Detached or Out-work, whoſe Sides open towards the Head or Campaign, or draw narrower or cloſer towards the Gorge. Of this kind are either ſingle or double Tenailles, and ſome Horn-Works, whoſe Sides are not parallel, but are narrow at the Gorge, and open at the Head, like the Figure of a *Swallow's Tail.*

When theſe Works are caſt up before the Front of a Place, they are defective in this Point, that they do not ſufficiently cover the Flanks of the oppoſite Baſtions; but then they are very well flanked by the Place, which covers all the Length of their Sides the better.

QUINCUNX, is that Poſition, or Aſpect, that the Planets are ſaid to be in, when they are diſtant from each other 150 Degrees, or 3 Sines, and is marked thus, V*c*, or Q.

QUINDECAGON, is a plain Figure of 15 Sides and Angles, which if they are all equal to one another, is called a *Regular Quindecagon.*

The Side of a *Regular Quindecagon*, ſo deſcribed, is equal in Power to the half Difference between the Side of the Equilateral Triangle, and the Side of the Pentagon; and alſo to the Difference of the Perpendiculars let fall on both Sides, taken together.

QUINQUEANGLED, in Geometry,

try, is a Figure consisting of five Angles.

QUINTILE, an Aspect of the Planets when they are 72 Degrees distant from one another, and is noted thus, C. or O.

QUINTUPLE, five-fold or five times as much as another thing.

QUOTIENT, is that Number in Division, which arises by dividing the Dividend by the Divisor: And is called the *Quotient*, because it answers to the Question, how often one Number is contained in another.

QUOIN, the Workman's Term for an Angle or Corner.

R.

RABANET. See *Rabine*.

RABINET, a Sort of Ordnance, whose Diameter at the Bore is $1\frac{1}{2}$ Inches, Weight 300 Pounds, Length 5 Foot, Load $\frac{3}{4}$ of a Pound, Shot something more than an Inch and a Quarter Diameter, and $\frac{1}{2}$ a Pound Weight.

RADIANT POINT, is the Point from which the *Divergent Rays* proceed.

RADIATION, signifies the casting forth of Beams, or Rays of Light; and in Optics, it is considered as threefold, *viz. Direct*, *Reflected*, and *Refracted*. See *Ray*.

RADIUS, in Geometry, is the Semi-Diameter, or half the Diameter of a Circle.

RADIUS of the Curvature of a Curve, is the Radius of a Circle that has the same Curvature in a given Point of the Curve, that the Curve has in that Point.

If any Equation is proposed expressing the Relation of the Abscis x, and correspondent Ordinate y, and the Equation be thrown into Fluxions, and you put 1 for $\dot{x}$, and z for $\dot{y}$ in that Equation; and if from the Equation that arises, you find the Relation between $\dot{x}$, $\dot{y}$, and $\dot{z}$; and at the same time put 1 for $\dot{x}$, and z for $\dot{y}$, as before. By the former Operation you will obtain the Value of $\dot{z}$; and if A be the Length of a Perpendicular to the Point of a Curve terminating at the Extremity of y, and intersecting the Abscis; then will $\frac{A^3}{\dot{z} \times y^3}$ be the Length of the Radius of the Curvature at the Extremity of y. For Example, let the Parabolic Equation be proposed, then will $a\dot{x} + 2b\dot{x}x - 2\dot{y}y = o$; and putting 1 for $\dot{x}$, and z for $\dot{y}$, it will be $2b - 2zz - 2\dot{z}y = o$. And again, writing 1 and z for $\dot{x}$ and $\dot{y}$, by the first we shall have $z = \frac{a + 2bx}{2y}$, and $\dot{z} = \frac{b - zz}{y}$. So that the Radius of the Curvature of this Curve at the Extremity of y will be $\frac{A^3}{y^2 \times \overline{b - zz}}$, and generally the Radius of the Curvature of Conic Sections is as A^3. See this Subject well handled in Sir *Isaac Newton*'s *Fluxions*, and the Marquis *de l'Hospital*'s *Infinimens Petits*.

RAINBOW, or *Iris*. The *Primary Iris* is only the Sun's Image, reflected from the Concave Surfaces of an innumerable Quantity of small spherical Drops of falling Rain, with this necessary Circumstance; that those Rays, which fall on the Drops, parallel to each other, should not after one Reflection, and two Refractions, *viz.* at going into the Drop, and coming out again, be dispersed, or made to diverge, but come back again, to the Eye, parallel to each other.

Some

Some of the Ancients, as we find in *Aristotle*'s *Meteors*, knew, that the Rainbow was caused by the Refraction of the Sun's Light in Drops of falling Rain. But it was more fully discovered and explained by *Antonius de Dominis*, in his Book *de Radiis Visûs & Lucis*, published at *Venice* by his Friend *Bartolus*, *Anno* 1611, and written above 20 Years before; wherein he shews how the interior Bow is made in round Drops of Rain by two Refractions of the Sun's Light, and one Reflection between them; and the exterior, by two Refractions and two Sorts of Reflections between them in each Drop of Water, and proves his Explications by Experiments made with a Phial full of Water, and with Globes of Glass filled with Water, and placed in the Sun to make the Colours of the two Bows appear in them. The same Explication has been pursued by *Descartes*, in his *Meteors*, who mended that of the exterior Bow; and he indeed was the first, that by applying Mathematics towards the Investigation of this surprizing Appearance, ever gave a tolerable Theory of the Rainbow. But as they did not understand the true Origin of Colours, Sir *Isaac Newton*'s Explication in his Optics at Prop. 9. is the best by much, where he makes the Breadth of the interior *Iris* to be nearly 2°. 15′, that of the exterior 3°. 40′, their Distance 8°. 25′, the greatest Semi-diameter of the interior Iris 42°. 17′, and the least of the exterior 50°. 42′, when their Colours appear strong and perfect.

Dr. *Barrow*, in his *Lectiones Opticæ*, at Let. 12. n. 14. tells us, that a Friend of his (by whom we are to understand Sir *Isaac Newton*) communicated to him a way of determining the Angle of the Rainbow (which was hinted to *Newton* by *Slusius*) without making a Table of the Refractions, as *Descartes* did. The Doctor shews the way; as also some other things (in *n*. 14. 15, 16) regarding the Rainbow, worth while to be perused, and agreeable to the elegant Genius's of those two great Men.

Concerning the Rainbow, see *Aristotle*'s *Meteors*, lib. 3. cap. 4, 5, 6, 7.— Dr. *Halley*'s Discourse in the *Philosophical Transactions*, n. 267.— Mr. *s'Gravesande*'s *Institutions* of the *Newtonian Philosophy*, lib. 3. cap. 20.

RAKED TABLE, a Term in Architecture. See *Table*.

RAMMER, is a Staff with a round Piece of Wood at one end, in order to drive home the Powder to the Breech of the great Gun; as also the Shot and the Wadding, which keeps the Shot from rolling out. At the other end of these Rammers are usually rolled in a certain Piece of Sheep's Skin fitted to the Bore of the Piece, in order to clear her after she has been discharged; and this is called *Spunging the Piece*.

RAMPART, in Fortification, is the Mass of Earth, which is raised about the Body of any Place, to cover it from great Shot, and consists of several Bastions and Curtains; having its Parapet, Platform, interior and exterior *Talus* and *Berme*; as also sometimes a Stone-Wall, and then they say it is lined. The Soldiers continually keep Guard here, and Pieces of Artillery are planted for the Defence of the Place.

The Height of the Ramparts must exceed three Fathom, as being sufficient to cover the Houses from the Batteries of the Cannon: Neither ought its Thickness to be above ten or twelve, unless more Earth be taken out of the Ditch, than can be otherwise bestowed.

The Ramparts of Half-Moons are the better for being low, that the small Fire of the Defendants may

the better reach the bottom of the Ditch; but yet it must be so high, as to be commanded by the Cover'd-way.

RANDOM-SHOT, is a Shot made when the Muzzel of a Gun is raised above the horizontal Line, and is not designed to shoot directly or point-blank. The utmost Random of any Piece, is about ten times as far as the Bullet will go point-blank.

The Distance of the Random is reckoned from the Platform to the Place where the Ball first grazes.

RANGE, a Term in Gunnery, signifying the Line a Shot goes in from the Mouth of the Piece: If the Bullet goes in a Line parallel to the Horizon, that is called the *Right* or *Level Range*; if the Gun be mounted to 45 Degrees, then will the Ball have the highest or utmost Range; and so proportionably all others between 60 Degrees and 45, are called the *Intermediate Ranges*.

1. If two Elevations are taken at equal Distances from 45 Degrees, one above, and the other below it, the Ranges shall be equal.

2. The greatest Altitude of a perpendicular Projection, is equal to half the greatest Range.

3. When Projectiles are thrown into the Air, the greater Range is at the Elevation of 44 Degrees and a half; the lower Ranges go farther than the upper correspondent Ranges, and the greatest Height of the perpendicular Projection is more than half the greatest Range. All these Irregularities are occasioned by the Resistance of the Medium.

RARE BODIES, are such as have more Space, or take up more room in proportion to their Matter, than other Bodies do.

RAREFACTION *of any Natural Body*, is when it takes up more Dimension, or a larger Space than it had before.

RASANT *Line of Defence*. See *Line of Defence Razant*.

RASH. See *Ratch*.

RATCH, is a sort of a Wheel of twelve large Fangs that runs concentrical to the Dial-Wheel, and serves to lift up the Dentes every Hour, and make the Clock strike; and are by some called *Rash*.

RATCHET, in a Watch, are the small Teeth at the bottom of the Fusee or Barrel, that stop it in winding up.

RATIO. When two Quantities are compared one with another, in respect of their Greatness or Smallness, that Comparison is called *Ratio*.

Euclid, in his fifth Element, says, that Ratio is the mutual Habitude of two Magnitudes of the same kind each to the other, according to Quantity. But I must confess this is somewhat obscure; for the word Habitude does not (in my opinion) readily convey an Idea of Ratio; the Meaning of this Word being almost as obscure as the thing defin'd by help of it. However, see *Euclid* defended concerning this Matter by Dr. *Barrow*, in his *Mathematical Lectures*, wherein he explains and clears it up, with a wonderful deal of Skill and profound Learning.

The greater A of two unequal Magnitudes A and B, has a greater Ratio to the same third Magnitude C; and the same third Magnitude C has a greater Ratio to the lesser B than to the greater A: for the Ratio of A to C being always expressed thus $\frac{A}{C}$, and of B to C thus $\frac{B}{C}$; it will be $\frac{A}{C}$ greater than $\frac{B}{C}$. And the Ratio of C to A being $= \frac{C}{A}$. But that if C to B equal to $\frac{C}{B}$

$\frac{C}{B}$; it will be $\frac{C}{A}$ leſs than $\frac{C}{B}$. Both theſe follow from the Nature of Fractions.

Of Magnitudes having Ratio to the ſame Magnitude, that which has the greater Ratio is the greater Magnitude, and that Magnitude to which the ſame Magnitude bears a greater Ratio, is the leſſer Magnitude.

It may not be amiſs to ſet down here the following uſeful Problem, *viz.*

To find a Series of Numerical Ratio's expreſſed in leſſer Numbers, conſtantly approaching to a given Numerical Ratio expreſſed in greater Numbers, whoſe Terms are prime to each other.

Let a be the leſſer Term, and b the greater of the given Ratio; now proceed with theſe two Numbers in the ſame manner as when you want to find their greateſt common Meaſure, by conſtantly dividing the greater Term by the leſs, and the Diviſor by the Remainder, thus

$$a)\, b\, (c + \frac{d}{a}$$

$$d)\, a\, (e + \frac{f}{d}$$

$$f)\, d\, (g + \frac{h}{f}$$

$$h)\, f\, (k + \frac{l}{h}$$

$$l)\, \frac{h}{n} (m + \frac{n}{l}, \text{ \&c.}$$

where c, e, g, k, m, &c. are the whole Numbers ariſing from the ſeveral Diviſions; and d, f, h, l, n, &c. the ſeveral Remainders; then will $\frac{b}{a}$ be exactly =

$$c + \cfrac{1}{e + \cfrac{1}{g + \cfrac{1}{k + \cfrac{1}{m + \frac{n}{l}, \text{ \&c.}}}}}$$

The firſt and moſt remote Ratio from the given one, being $\frac{c}{1}$, the ſecond nearer approaching is $c + \frac{1}{e}$, the third ſtill nearer is $c + \cfrac{1}{e + \frac{1}{g}}$, the fourth nearer yet, is $c + \cfrac{1}{e + \cfrac{1}{g + \frac{1}{k}}}$, and the fifth ſtill nearer, is

$$c + \cfrac{1}{e + \cfrac{1}{g + \cfrac{1}{k + \cfrac{1}{m + \frac{n}{l}, \text{ \&c.}}}}}$$

and ſo on. When theſe Fractions are each reduced on more ſimple ones.

For $c + \frac{d}{a} \left(= \frac{b}{a}\right)$ is $= c + \cfrac{1}{\frac{a}{d}}$. But $\frac{a}{d} \left(= e + \frac{f}{d}\right)$ is $= e + \cfrac{1}{\frac{d}{f}}$. But $\frac{d}{f} \left(= g + \frac{h}{f}\right)$ is $= g + \cfrac{1}{\frac{f}{h}}$. But $\frac{f}{h} \left(= k + \frac{l}{h}\right)$

 is

RAT

is $= k + \cfrac{1}{\frac{h}{f}}$. But $\frac{h}{l}\left(= m + \frac{n}{l}\right)$ is $= m + \cfrac{1}{\frac{l}{n}}$, &c. therefore $\frac{b}{a}$ is $=$

$$c + \cfrac{1}{e + \cfrac{1}{g + \cfrac{1}{k + \cfrac{1}{m + \frac{n}{l}}}}}, \text{ \&c.}$$

An Example in Numbers. Let it be required to find a Series of Ratio's in lesser Numbers constantly approaching to the Ratio of 100000 to 314159, being one of the approximating Ratio's of the Diameter of a Circle to the Circumference.

100000) 314159 (3 $= c$
$d =$ 14159) 100000 (7 $= e$
$f =$ 887) 14159 (15 $= g$
$h =$ 854) 887 (1 $= k$
$l =$ 33) 854 (15 $= m$
29) 33 (1 $= p$
$n =$ 4) 29 (7 $= q$
1) 4 (4 $= r$

that is $\frac{314159}{100000}$ will be $=$

$$3 + \cfrac{1}{7 + \cfrac{1}{15 + \cfrac{1}{1 + \cfrac{1}{15 + \cfrac{1}{1 + \cfrac{1}{7 + \frac{1}{4}}}}}}}$$

So that the first and most remote Ratio from the Truth will be $\frac{1}{3}$, or that of 1 to 3; the second will be $3 + \frac{1}{7} = \frac{22}{7}$, or that of 7 to 22 being nearer; the third will be $3 + \cfrac{1}{7 + \frac{1}{15}} = \frac{333}{106}$, or that of 106 to 333 still nearer; the fourth will be $=$

$$3 + \cfrac{1}{7 + \cfrac{1}{15 + \frac{1}{1}}}$$

$= \frac{355}{113}$, or that of 113 to 355 nearer still; the fifth will be $=$

$$3 + \cfrac{1}{7 + \cfrac{1}{16 + \frac{1}{15}}}$$

$= \frac{5347}{1702}$, or that of 1702 to 5347, nearer yet; the sixth will be $=$

$$3 + \cfrac{1}{7 + \cfrac{1}{16 + \frac{1}{10}}}$$

$= \frac{5702}{1815}$, or that of 1815 to 5702, still nearer; and so on till you get $\frac{314159}{100000}$ the given Ratio.

Lest this way of adding up the several Diagonal Fractions may appear difficult to some, they may use the following Rule. After you have proceeded with the given Ratio expressed Fraction-wise, as if in quest of the greatest common Measure of the Fraction, the first Quotient divided by Unity will be the fractional

fractional Expression of the first and most remote (from the Truth) approximating Ratio, whose Terms being each multiplied by the second Quotient, and Unity being added to the Numerator, gives the second fractional Expression of the Ratio, approaching to the given one; ever after having two fractional Expressions found, as suppose the first and second to find the third; multiply the Terms of the second Fraction by the third Quotient, and adding to the Terms of the same, the first fractional Expression, and this will give you a third fractional Expression of the Ratio. So also having the second and third fractional Expressions; to find a fourth, multiply the Terms of the third Fraction by the fourth Quotient, adding in the Terms of the second Fraction, and this gives a fractional Expression for a fourth Ratio; and thus you may proceed till you have got the last fractional Expression of the given Ratio.

For Example, let the Ratio given be as 5978 to 97435, or $\frac{97435}{5978}$

5978) 97435 (16 . . 1st Quot.
1787 (5978) 3 . . . 2d.
617) 1787 (2 . . . . 3d.
153 (617) 1 . . . . 4th.
64) 553 (8 . . . 5th.
41 (64) 1 . . 6th.
23) 41 (1 . . 7th.
18) 23 (1 . 8th.
5) 18 (3 . 9th.
3) 5 (1 . 10th.
2) 3 (1 . 11th.
1) 2 (1 . 12th.

$\frac{16}{1}$ the first Fraction.

$\frac{16 \times 3 + 1}{1 \times 3} = \frac{49}{3}$ the second.

$\frac{49 \times 2 + 16}{3 \times 2 + 1} = \frac{114}{7}$ the third.

$\frac{114 \times 1 + 49}{7 \times 1 + 3} = \frac{163}{10}$ the fourth.

$\frac{163 \times 8 + 114}{10 \times 8 + 7} = \frac{1418}{87}$ the fifth.

$\frac{1418 \times 1 + 163}{87 \times 1 + 10} = \frac{1581}{97}$ the sixth.

$\frac{1581 \times 1 + 1418}{97 \times 1 + 87} = \frac{2999}{184}$ the seventh; and so on.

Dr. Wallis *in a little Piece at the End of* Horrox's *Astronomy, treats of the Nature and Solution of this Problem, with a great deal of tedious Preparation and unnecessary Circumlocution, almost enough to discourage a Person from attempting to apprehend what he has a mind to be at. The great Mr.* Huygens *too has given a Solution, and the Reason thereof; but after a much shorter and more natural way. So also has Mr.* Cotes *at the Beginning of his* Harmon. Mensur. *But from more intricate and mystical Principles, using therein unintelligible and unnessary ways of Expression; such, as the Ratio of* 1 *to* 0; *and of* 2 *to* 0. *The Problem is of much use, in expressing a Ratio in small Numbers, that shall be near enough in practice, to any gi-*

ven Ratio in great Numbers; *such as that of the Diameter of a Circle to the Circumference*; *of the Square of the Diameter to the Area*; *of the Cube of the Diameter of a Sphere to the Solidity, and many other useful Ratios, too many to mention here, or even for me to think of.*

RATIONAL HORIZON. See *Horizon.*

RATIONAL QUANTITIES. Any Quantity being proposed, for which we may always put 1, and which *Euclid* (*Book* X.) calls *Rational*, there may be infinite others, which are commensurable, or incommensurable to it; and that either simple, or in Power. Now, all such as are commensurable any how to the given Quantity, he calls *Rational Quantities*, and all the others *Irrational.*

RAVELIN, in Fortification, is a small Triangular Work composed only of two Faces, which make a saliant Angle, without any Flanks. It is generally raised before the Curtains or Counterscarp, and commonly called a *Half-Moon* by the Soldiers.

A Ravelin is like the Point of a Bastion with the Flanks cut off. The Reason of its being placed before a Curtain, is to cover the opposite Flanks of the two next Bastions. 'Tis used also to cover a Bridge, or a Gate; and 'tis always placed without the Moat.

What the Engineers call a *Ravelin*, the Soldiers generally call a *Half Moon*; which see.

RAY *of Refraction, or Broken Ray*, is a Right Line, whereby the *Ray of Incidence* changeth its Rectitude, or is broken in traversing the second Medium, whether it be thicker or thinner.

RAYS, *or* BEAMS *of the Sun, or* RAYS *of Light*, are either according to the Atomical Hypothesis, those very minute Particles, or Corpuscles of Matter, which continually issuing out of the Sun, do thrust on one another all round in physical short Lines; and that this is the right Opinion, many Experiments do evince, particularly Sir *Isaac Newton*'s about Light and Colours; or else, as the *Cartesians* assert, they are made by the Action of the Luminary on the contiguous Æther and Air, and so are propagated every way in straight Lines, through the Pores of the Medium.

RAYS CONVERGENT. See *Converging Rays.*

RAYS DIVERGENT. See *Diverging Rays.*

REACH, is the Distance between any two Points of Land, that lie in a Right Line one from another.

RECESSION *of the Equinoxes*, is the going back of the Equinoctial Points every Year about fifty Seconds.

RECIPROCAL FIGURES, in Geometry, are such as have the Antecedents and Consequents of the Ratio in both Figures.

RECIPROCAL PROPORTION, is when, in four Numbers, the fourth is lesser than the second, by so much as the third is greater than the first, and *vice versa.*

RECLINATION *of a Plane*, is the Quantity of Degrees which any Plane, on which a Dial is supposed to be drawn, lies or falls backwards from the truly upright or vertical Plane.

RECLINING, in Dialling. The Plane that leans from you when you stand before it, is said to be a *Reclining Plane.*

RECLINING DECLINING DIALS. See *Declining Reclining Dials.*

RECTANGLE, in Arithmetic, is the same with *Product*; which see.

RECTANGLES, in Geometry, are Parallelograms, whose Sides are unequal; but Angles right Their Area is found by multiplying the

two

two unequal Sides one into another, for then the Product is the superficial Content or Area.

Rectangled Triangle; the same with *Right-angled Triangle*.

Rectangular, or Right-Angled, is spoken of a plain Figure in Geometry, when one or more of its Angles are right: Of Solids, 'tis spoken in respect of their Situation; for, if their Axis be perpendicular to the Plane of the Horizon, they are therefore rectangular, as right Cones, Cylinder, *&c.*

Rectangular Section *of a* Cone; by this the ancient Geometers always meant a Parabola, which Conic Section, before *Apollonius*, was only considered in a Cone, whose Section by the Axis would be a Triangle, right-angled at the Vertex. And hence it was, that *Archimedes* entitled his Book *Of the Quadrature of the Parabola,* (as 'tis now called) by the Name of *Rectanguli Coni Sectio.*

Rectify, is a Word used in the Description and Use of the Globe, or Sphere. For the first thing to be done before any Problems can be wrought on the Globe, is to rectify it; that is, to bring the Sun's Place in the Ecliptic on the Globe, to the graduated Side of the Brass Meridian, to elevate the Pole above the Horizon, as much as is the Latitude of the Place, and to fit the Hour-Index exactly to Twelve at Noon, screwing also the Quadrant of Altitude, (if there be occasion) to the *Zenith.*

All this is comprehended under the Word *Rectify the Globe:* And when this is done, the Celestial Globe represents the true Posture of the Heavens, for the Noon of that Day it is rectified to.

Rectifier, in Navigation, is an Instrument consisting of two Parts, which are two Circles, either laid upon, or let into the other, and so fasten'd together in their Centres, that they represent two Compasses, one fixed, the other moveable; each of them divided into the 32 Points of the Compass, and 360 Degrees, and number'd both ways, both from the North and the South, ending at the East and West, in 90 Degrees.

The fixed Compass represents the Horizon, in which the North, and all the other Points of the Compass are fixed and immoveable.

The Moveable Compass represents the Mariner's Compass, in which the North, and all the other Points are liable to Variation.

In the Centre of the moveable Compass is fasten'd a Silk Thread, long enough to reach the outside of the fixed Compass; but, if the Instrument be made of Wood, there is an Index instead of the Thread. Its Use is to find the Variation of the Compass, to rectify the Course at Sea, having the Amplitude or Azimuth given.

Rectifying *of Curves*, in Mathematics, is to find a straight Line, equal to a curved one.

The first who gave the Rectification of any Curve was Mr. *Neal*, a Son of Sir *Paul Neal*, as we find at the End of Dr *Wallis*'s Treatise of the *Cissoid*; wherein the Doctor says, that Mr. *Neal*'s Rectification of the Curve of the semi-cubical Parabola, was published in *July* or *August*, 1657. Two Years after, *viz. Anno* 1659, *Van Haureat*, in *Holland*, gave the Rectification of this Curve; as may be seen in *Schouten*'s Commentary upon *Descartes*'s Geometry.

Rectilineal, or Right-Lined, in Geometry, is spoken of such Figures as have their Extremities all Right-Lines.

Redent, in Fortification, is a Work made in form of the Teeth of a Star, with saliant and re-entring

 Angles,

Angles, to the end that one Part may defend another. These sort of Works are usually erected on that side of a Place which looks towards a Marsh, or River.

REDOUBT, in Fortification, is a small Fort of a square Figure, having no Defence but in the Front; its Use being to maintain the Lines of Circumvallation, Contravallation, and Approach.

In marshy Grounds, these Redoubts are often made of Mason's Work, for the Security of the Neighbourhood. Their Face consists of from ten to fifteen Fathom, the Ditch round about being from eight to nine Foot broad and deep, and their Parapets having the same Thickness.

REDUCTION, in Astronomy, is the Difference between the Argument of Inclination, and the eccentrical Longitude; that is to say, the Difference of the two Arches of the Orbit, and the Ecliptic, intercepted between the Node and the Circle of Inclination.

REDUCTION, in Arithmetic, is the manner of converting or bringing one Species of Money, Weight, or Measure, into another; that from a greater to a less, being perform'd by Multiplication; but from a less to a greater, by Division.

REDUCTION *of Equations*, in Algebra, is the clearing of them from all superfluous Quantities, and the separating of the known Quantities from the unknown, to the end that at length every respective Equation may remain in the fewest and simplest Terms; and so disposed, that the known Quantities may possess one Part thereof, and the unknown the other.

RE-ENTRING ANGLE, a Term in Fortification. See *Angle*.

REFLECTION, in general, is the Regress or Return that happens to a moving Body, because of the meeting of another Body, which it cannot penetrate. Thus the material Rays of Light are reflected variously from such Bodies as they cannot pass through.

REFLECTION *of the Rays of Light*. Sir *Isaac Newton* finding, by Experiment, that Light was an heterogeneous Body, consisting of a Mixture of differently refrangible Rays; and consequently concluding that no further Improvement could well be made in optical Instruments in the dioptric way, he took Reflections into Consideration, and tells us, that by their Help, Optic Instruments might be brought to any Degree of Perfection; if we could but find a reflecting Substance, which would polish as finely as Glass, reflect as much Light as Glass transmits, and be formed into a parabolical Figure.

An Experiment of which, he made in the kind of a catoptric Telescope, and by which, tho' not above two Foot long, he could (he saith) discern the *Jovial* Satellites, and the Phases of *Venus*. *Philos. Trans.* N° 18.

REFLECTED RAY, *or Ray of Reflection*, is that whereby the Reflection is made upon the Surface of a reflecting Body.

REFLECTING, or *Reflexive Dials*, are made by a little Piece of Looking-glass-Plate, duly placed, which reflects the Sun's Rays to the top of a Ceiling, *&c.* where the Dial is drawn. This Glass should be as thin as can well be ground.

REFLECTING TELESCOPES. See *Telescopes*.

REFLECTION *of the Moon*, is (according to *Bullialdus*) her third Inequality of Motion. This *Tycho* calls by the Name of her *Variation*. Which see.

REFLUX *of the Sea*, is the Ebbing of the Water off from the Shore; as its coming on upon it, or Tide of

of Flood, is called the *Flux of the Sea*. See *Tide*.

REFRACTED ANGLE, in Optics, is the Angle contained between the refracted Ray and the Perpendicular.

REFRACTION *in general*, is the Incurvation or Change of Determination in the Body moved, which happens to it whilst it enters or penetrates any Medium.

In Dioptrics, it is the Variation of a Ray of Light, from that Right Line which it would have passed on in, had not the Density of the Medium turned it aside.

REFRACTION ASTRONOMICAL, is that which the Atmosphere produceth, whereby a Star appears more elevated above the Horizon, than really it is.

REFRACTION HORIZONTAL, is that which causeth the Sun or Moon to appear on the Edge of the Horizon, when they are as yet somewhat below it.

REFRACTION *from the Perpendicular*, is when a Ray falling inclined from a thicker Medium into a thinner, in breaking departs further from that Perpendicular. And

REFRACTION *to the Perpendicular*, is when it falls from a thinner into a thicker, and so comes nearer the Perpendicular.

REFRANGIBLE, is whatever is capable of being refracted.

REGEL, or RIGEL, a fixed Star of the first Magnitude in *Orion*'s Left-foot, its Longitude is 72 Degrees, 19 Minutes, Latitude 30°. 10′.

REGION, is taken for our Hemisphere, or the Space within the four Cardinal Points of the Heavens, or of the Air, *&c*.

In Geography, it signifies a large Extent of Land inhabited by many People of the same Nation, and inclosed within certain Limits or Bounds.

REGION ÆTHEREAL, in Cosmography, is the vast Extent of the Universe; wherein are comprized all the Heavens and Cœlestial Bodies.

REGION ELEMENTARY, according to the *Aristotelians*, is a Sphere terminated by the Concavity of the Moon's Orb, comprehending the Earth's Atmosphere.

REGULAR BODY, is a Solid, whose Surface is composed of regular and equal Figures; whose solid Angles are all equal. Such as the Tetrahedron, Hexahedron, Octohedron, Dodechahedron, and Icosahedron. There can be no more regular Bodies besides these.

REGULAR FIGURES, in Geometry, are such whose Sides, and consequently their Angles, are all equal to one another. Whence all regular multilateral Planes are called *Regular Polygons*.

The Area of such a Figure is speedily found by multiplying a Perpendicular let fall from the Centre of the inscribed Circle to any Side by half that Side; and then that Product by the Number of the Sides of the Polygon.

REGULAR FORTIFICATION. See *Fortification*.

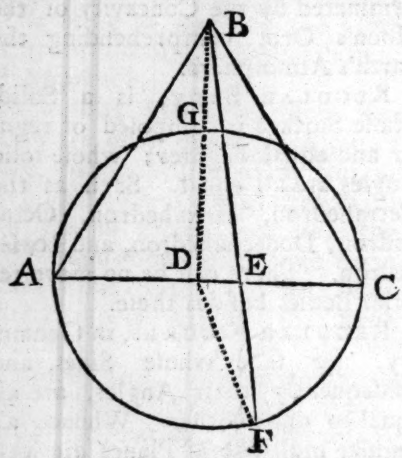
REGULAR POLYGON. The Truth of the general Method of *Sturmius* and *Rhenaldinus* for inscribing any regular Polygon in a Circle may be trigonometrically examined thus: Suppose A C G a Circle, D the Centre, A C the Diameter, A B C an equilateral Triangle described upon the Diameter, E the second Point of Division of the Diameter divided into any Number of equal Parts, D B perpendicular to A C, and the Points D, F, joined.

1. Now, because the Semi-Diameter D C, and the whole Diameter B C are given; B D may be had, which is equal to the square

Root

Root of the Diameter $\overline{AC}^2 (=\overline{BC}^2,) - DC_q$.

2. Again, because the Number of equal Parts, the Diameter is divided into, for any given Polygon is alfo given; the Line CE, which is equal to two of thofe Parts will be



given, and confequently the Part DE will be had. Then in the right-angled Triangle BDE, there are given the Sides BD, and DE, to find the Angle DBE, in faying, As DB is to DE: So is the Radius to the Tangent of DBE. Moreover, in the Triangle DBE, becaufe the Sides BD, and DF, and the Angle DBE, being now found, are given, the Angle BFD may be found: in faying, As DF is to DB: So is the Sine of the Angle DBE to the Sine of the Angle BFD, which being found, add it to the Angle DBF, and fubtract the fame from 180 Degrees; the Remainder is the Angle BDF: then fubtracting the Angle BDE, which is a right Angle, from the Angle BDF, and there remains the Angle at the Centre CDF. For Example, to examine this for a Pentagon, let us fuppofe the Diameter AC, or CB, to be 1000, then the Log. BD = 2.937532. Again, CE = 400, and confequently DE = 100. Now fay, As DB, Log. 2.937532 is to DE, Log. 2.000000: So is the Radius 10.000000 to the Logar. Tangent of the Angle DBE, *viz.* 6°. 35′.

3. Again, As DF, Log. 2. 699404, is to DB, Log. 2.237532: So is the Sine of DBE, Log. 9.059267, to Log. Sine of the Angle DFE, which will be 11°. 26′. Now, the Sum of thefe Angles taken from 180°, will be the Angle FDB = 161°. 59′. From which, if 90° be taken, there remains 71°. 59′, for the Quantity of the Angle FDC at the Centre; but this wants 1′ only of being 72°, the true Angle: and the greater the Number of Sides is, the greater will the Error be; fo that if the Number be 20, the Error will be half a Degree and more.

Regulator, is a fmall Spring belonging to the Balance in the Pocket-Watches.

Relais, a *French* Term in Fortification; the fame with *Berme.*

Relation Inharmonical, a Term in Mufical Compofition, fignifying a harfh Reflection of flat againft fharp, in a crofs Form, *viz.* when fome harfh and difpleafing Difcord is produced, in comparing the prefent Note of another Part.

Relative Gravity, the fame with *Specific.* Which fee.

Residual Figure, in Geometry, fignifies the remaining Figure after the Subtraction of a leffer from a greater.

Residual Root, in Mathematics, is one compofed of two Parts or Members, only connected together with the Sign —: Thus $a-b$, or 5—3, is a Refidual Root; and is fo called, becaufe its true Value is no more than its Refidue or Difference between the Parts a and b.

Resistance *of a Medium*, is the Oppofition againft, or Hindrance of

of the Motion of any Body moving in a Fluid, as in the Air, the Water, the Æther, &c. and this, together with the Gravity of Bodies, is the Cause of the Cessation of the Motion of Projectiles, &c. This Resistance in Mediums, which are very dense and rigorous, so that Bodies can there move but very slowly, is nearly as the Velocity of the moving Body: But in a Medium free from all such Rigour, as the Squares of the Velocities. *Newt, Princip.* p. 245.

1. If an Isosceles Triangle be moved in a Fluid according to the Direction of a Line which is normal to its Base; first with the Vertex foremost, and then with its Base, the Resistances will be as the Sides.

2. The Resistance of a Square moved according to the Direction of its side, and of its Diagonal, is as the Diagonal to the Side.

3. The Resistance of a Circular Segment, (less than a Semi-circle,) carried in a Direction perpendicular to its Base, when it goes with the Base foremost, and when with its Vertex foremost, (the same Direction and Celerity continuing, which is all along supposed,) is as the Square of the Diameter to the same, less $\frac{1}{3}$ of the Square of the Base of the Segment.

4. Hence the Resistance of a Semi-Circle, when its Base, and when its Vertex goes foremost, are to one another in a sesquialteral Ratio.

5. A Parabola moving in the Direction of its Axis, with its Base, and then its Vertex foremost, hath its Resistance as the Tangent to an Arch of a Circle, whose Diameter is equal to half the Base of the Parabola.

6. The Resistance of an Hyperbola, or Semi-Ellipsis, when the Base and when the Vertex goes foremost, may be thus computed: Let it be, as the Sum (Difference) of the transverse Axis, and *Latus Rectum*, is to the transverse Axis :: So is the Square of the *Latus Rectum* to the Square of the Diameter of a certain Circle, in which Circle apply a Tangent equal to half the the Base of the Hyperbola or Ellipsis.

7 Then say again, As the Sum and Difference of the Axis, and again, as the Sum (or Difference) of the Axis and Parameter, is to the Axis :: So is the circular Arch corresponding to the aforesaid Tangent, to another Arch This done, the Resistances will be as the Tangent to the Sum (or Difference) of the Right Line thus found, in that Arch last mentioned.

8. In general, the Resistances of any Figure whatsoever, going now with its Base foremost, and then with its Vertex, are as the Figures of the Base is to the Sum of all the Cubes of the Elementa of the Base divided by the Squares of the Elementa of the Curve-Line.

Resolvend, a Term in the Extraction of the Square and Cube-Roots, &c. signifying that Number which arises from augmenting the Remainder after Subtraction, by drawing down the next Square, Cube, &c. and writing it after the said Remainder.

Resolution, in Mathematics, is a Method of Invention, whereby the Truth or Falshood of a Proposition, or its Possibility or Impossibility is discovered, in an Order contrary to that of Synthesis or Composition: For in this Analytical Method, the Proposition is proposed as already known, granted, or done; and then the Consequences thence deducible are examined, till at last you come to some known Truth or Falshood, or Impossibility, whereof that which was proposed is a necessary Consequence, and from thence justly conclude the Truth or Impossibility

ſibility of the Propoſition; which if true, may then be demonſtrated in a ſynthetical Method. This Method of Reſolution conſiſts more in the Judgment, Penetration, and Readineſs of the Enquirer or Artiſt, than in any particular Rules; tho' thoſe of Algebra are of neceſſary uſe, and a good Treaſure of Geometry in his Head will be of great advantage to him in all manner of Inveſtigations.

REST, (in Muſic) See *Pauſe*.

RESTITUTION; the returning of elaſtic Bodies forcibly bent to their natural State, is called the *Motion of Reſtitution*.

RETIRED FLANK. See *Flank*.

RETRENCHMENT, in Fortification, is a Ditch bordered with its Parapet, and ſecured with Gabions or Bavins laden with Earth. It is ſometimes taken for a ſimple Retirade in part of the Rampart, when the Enemy is ſo far advanced, that he is no longer to be reſiſted, or beaten from his Poſt.

RETROCESSION, *of the Equinoxes*, is the annual going backward of the Equinoctial Points about 50 Seconds. See *Equinoxes*.

RETROGRADE in Aſtronomy, is uſually appropriated to the Planets, when by their proper Motion in the Zodiac, they move backward or contrary to the Succeſſion of the Signs: As from the ſecond Degree of *Aries* to the firſt, *&c.*

But this Retrogradation is only apparent, and occaſioned by the Obſerver's Eye being placed on the Earth: For to an Eye at the Sun, the Planet will appear always direct, and never either ſtationary or retrograde.

REVERSED TALON. See *Talon*.

REVERSION *of Series*, in Algebra, is a Method to find a Number from its Logarithm, being given; or the Sine from its Arch: The Ordinate of an Ellipſis, from an Area given to be cut off from any Point in the Axis, *&c.*

REVOLUTION: In Geometry, the Motion of any Figure round a fixed Line, (which is called therefore its *Axis*,) is called the *Revolution of that Figure*; and the Figure ſo moving is ſaid to revolve. Thus a right-angled Triangle revolving round one of its Legs, as an Axis, generates by that Revolution a Cone. And to inſtance in a caſe very wonderful; the Body called by TORRICELLIUS *Hyperbolicum Acutum*, tho' itſelf, (as he demonſtrates,) be finite, is yet formed by the Revolution of an infinite Area.

RHOMB SOLID, is two equal and right Cones joined together at their Baſes.

RHOMBOIDES, a Figure in Geometry. See *Quadrilateral Figures*.

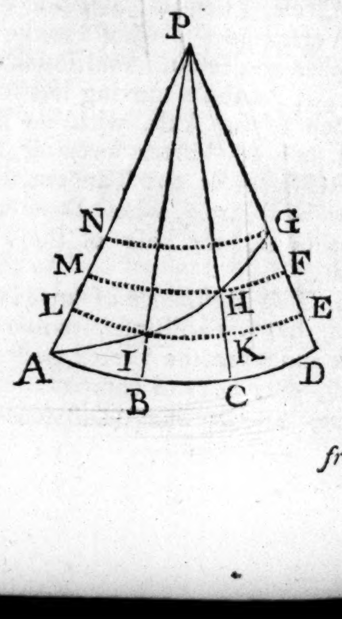
RHOMBUS. See *Quadrilateral Figures*.

RHOMBS. See *Rhumbs*.

The following Propoſitions being of great uſe in the Theory of Navigation, and not to be found every where, I thought it would not be amiſs to inſert them with their Demonſtrations here.

PROP. I.

If the Meridians PA, PB, PC, PD, *&c. be at a ſmall diſtance*



from

from each other, then the Rhumb-Line AIHG *is divided into equal Parts* AI, IH, GH, *by Parallels,* LE, MF, NG, *&c. at the equal Distances,* BI, HK, GF *from each other.*

This is plain, because the Angles B, H, F, being right ones, and PAG =PIG=PHG, and the Arches AB, BC, CD, being very small, the Triangles AIB, IHK, HGF, may be taken for right-lined ones.

PROP. II.

The Length of the Rhumb-Line AG, *is to the Difference of Latitude* GD, *in the same Measure, as the Radius is to the Cosine of the Course or Angle* PAG.

For in the Triangles AIB, IHK, and GHF, as the Radius is to the Sine of the Angles BAI, KIH, FGH, that is, to the Cosine of the Course PAG, or PIG, or PLG, PHG, so are the Parts of the Rhumb-Line AI, IH, GH, to the Parts IB, KH, GF, of the Difference of Latitude. Therefore AI + IH + GH, that is the Rhumb-Line AG, is to IB + KH + GF. That is the Difference of Latitude DG, as the Radius is to the Cosine of the Course.

PROP. III.

The Length of the Rhumb-Line AG *is to the Sum of the Bases of the small Right-lined Triangles,* viz. *to* AB + IK + HF *as the Radius to the Sine of the Angle* GAP, *or Course.*

From the Demonstration of the last Theorem, it is manifest, that the Radius is to the Sine of the Course, as AI to AB, IH to IK, or GH to HF: (That is, since IAB is the Complement of the Course GAP to a right Angle PAD, and because B is a right Angle, and also AIB the Complement of BAI to a right Angle, and therefore AIB is equal to the Course PAG.) So is AI + IH + GH, that is, AG, to AB + IK + HF.

PROP. IV.

The Difference of Latitude DG *is to the Sum of* AB + IK + HF, *&c. as the Radius is to the Tangent of the Course* PAG, *or* AIB.

From the Demonstration of the second Theorem, it is manifest, that the Radius is to the Tangent of the Course AIB, as IB to AB, HK to KI, GF to FH. Therefore, also, as the Radius is to the Tangent of the Course, so is IB + HK + GF, that is, the Difference of Latitude GD to AB + IK + HF.

PROP. V.

The Sum of AB + IK + HF *is a mean Proportional between the Aggregate of the Distance* AG *and the Difference of Latitude* GD, *and their Sum.*

For $\overline{AI}^2 - \overline{IB}^2 = \overline{AB}^2$, and so AI + IB : AB :: AB : AI − IB. Wherefore since after the same manner it is proved that IH + HK : IK :: IK : IH − HK, and GH + GF : HF :: HF : GH − GF; therefore shall AI + IH + HG + IB + HK + GF be to AB + IK + HF, as AB + IK + HF to AI + IH + HG − IB − HK − GF; that is, AG + GD : AB + IK + HF :: AB + IK + HF : AG − GD.

From hence it follows, even in plain Sailing, that of these three things, *viz.* the Difference of Latitude, Course, and Distance, any two being given, the other will be had by one Operation of the Golden Rule, to a Geometrical Exactness. But the Departure which is represented by the Line AD, will not be found by the common Canon in plain or *Mercator*'s Sailing.

Rideau, in Fortification, is a Ditch, the Earth whereof is raised on its side, or it is a small Elevation of Earth, extending itself in Length

Length on a Plain, which serves to cover a Post; being also very convenient for those that would besiege a Place at a near distance; and to secure the Workmen in their Approaches to the Fort of a Fortress.

RIGHT-ANGLED, a Figure is said to be right-angled, when its Sides are at right Angles, or stand perpendicularly one upon another: And this is sometimes in all Angles of the Figures, as in Squares and Rectangles; sometimes only in part, as in right-angled Triangles.

RIGHT-ANGLED TRIANGLE. See *Triangle*.

1. In the following two Progressions, *viz.*

$1\frac{1}{3}.\ 2\frac{2}{5}.\ 3\frac{3}{7}.\ 4\frac{4}{9}.\ 5\frac{5}{11}.\ 6\frac{6}{13}$, &c.

$1\frac{7}{8}.\ 2\frac{11}{12}.\ 3\frac{15}{16}.\ 4\frac{19}{20}.\ 5\frac{23}{24}.\ 6\frac{27}{28}.$ &c.

If the Denominator of the Fraction be taken for the Base, and the Integer multiply'd by the Denominator *Plus* the Numerator for the Perpendicular of any right-angled Triangle, the Hypotheneuse will be a rational Number.

2. And after the following manner may an infinite Number of such Series of mixed Numbers, or improper Fractions be found, *viz.* having taken two Terms of any Ratio, in order to find the Numerator, multiply one of the Terms by the other, and observe whether the Product be even or odd; if it be odd, it will be the Numerator itself; but if it be even, it will be the double of the Product: But to get the Denominator, add the said Terms of the Ratio together, and multiply the Sum, if it be odd by the Difference of the Terms, and that Product will be the Denominator; but if that Sum be even, half of the Sum will be the Denominator.

3. Now, to obtain a second Numerator, multiply the Difference of the Terms by 2; if it be even, or by 4, if odd; and if the Product be multiplied by the greater Term, this last Product added to the Numerator first found, and you will have a second Numerator.

4. *Lastly*, To have a second Denominator, add the Square of the Difference of the Terms; if it be even, or the double of it, if odd, to the Denominator first found, and that will be a second Denominator.

5. For Example, if the Terms of the Ratio be 1 and 2, these multiplied, make 2, and so 4 shall be the first Numerator. Again, since 1 and 2 added is 3, an odd Number; therefore, 3 multiplied by 1, the Difference of the Terms is 3, the Denominator. Whence the first Term of the Series will be $\frac{4}{3}$ or $1\frac{1}{3}$. Again, because 1 the Difference of the Terms is odd; if it be multiplied by 4, and this Product 4 by 2, the greater Term; 12 the Sum of this Product, and the first Numerator, shall be the second Numerator.

6. *Lastly*, Because 1, the Square of the Difference of the Terms, is odd; therefore, if the double of it 2, be added to the Denominator 3 before found, the Sum 5 shall be the second Denominator, where $\frac{4}{3}$ and $\frac{12}{5}$, each of them, express two Sides of a right-angled Triangle, whose Hypotheneuse is rational; and if the Terms of the Ratio, *viz.* 2 to 3, 3 to 4, 4 to 5, &c. be used; after this way you will get the Terms of the first Series above.

RIGHT ANGLE. See *Angles*.

RIGHT ASCENSION *of the Sun, or Star*, is that Degree of the Equinoctial, accounted from the Beginning of *Aries*, which riseth with it in a right Sphere.

Or, 'tis that Degree and Minute of the Equinoctial (counted as before) which cometh to the Meridian, with the Sun or Stars, or with any Point of the Heavens. The

Reason of which referring it to the Meridian, is because that is always at right Angles to the Equinoctial; when the Horizon only is in a right or direct Sphere.

RIGHT CIRCLE, in the stereographical Projection of the Sphere, is a Circle that is at Right Angles, to the Plane of Projection, or that which passes thro' the Eye.

RIGHT LINE, is the nearest Distance between any two Points. See *Line*.

RIGHT SAILING, is when a Voyage is performed on some one of the four Cardinal Points.

RIGHT SINE, the same with *Sine*; which see.

RIGHT, or DIRECT SPHERE, is that which has the Poles of the World in its Horizon, and the Equator in the Zenith: The Consequence of living under such a Position, (as those who live directly under the Line are in,) is that they have no Latitude, nor Elevation of the Pole. They can see nearly both Poles of the World; all the Stars do rise, culminate, and set with them; and the Sun always rises and descends at Right-Angles to their Horizon, and makes their Days and Nights equal; because the Horizon bissects the Circle of this Diurnal Revolution.

RIM, in a Watch or Clock, is the Circular Part of the Balance thereof.

RING-DIAL. See *Universal Equinoctial Dial*.

RING *of Saturn*, is an opacous, solid, circular Arch or Plane, like the Horizon of a Globe of Matter, entirely encompassing round the Planet, and no where touching it; its Plane is at this time nearly parallel to the Plane of our Earth's Equator; the Diameter of this Ring is $2\frac{1}{4}$ of *Saturn*'s Diameters, and the Distance of the Ring from the Planet, is about the Breadth of the Ring itself. *Galilæus* first discovered the Figure of *Saturn* not to be round; but, that the Inequality was thus in the Form of a Ring, Mr. *Huygens* first found out, and published in his *Systema Saturniana*, 1659. 'Tis this Ring, and its various Positions in respect of the Sun, (whose Light it reflects like the Body of *Saturn* itself) and of the Eye of the Spectator, which occasions all the various Appearances of *Saturn* with his *Ansæ*, (as they call them) or with none; with broad or narrow ones, &c.

RISING *of the Sun or Star*, is their appearing above the Horizon.

ROD, a Measure of Length containing by Statute just sixteen Feet and a half *English*: See *Pole*. This must carefully be distinguished from Rood, which is a square Measure, containing the fourth Part of an Acre.

ROMAN ORDER, in Architecture, is the same with the *Composite*. 'Twas invented by the *Romans*, in the time of *Augustus*, and set above all the others, to shew that the *Romans* were Lords over other Nations: 'Tis made up of the *Ionic* and *Corinthian* Orders, and is more ornamental than either.

RONDEL, in Fortification, is a round Tower, sometimes erected at the foot of the Bastions.

ROOD, a square Measure, containing just a quarter of an Acre of Land: Some confound this Measure with a Rod, which is the Length of sixteen Foot and a half; and others with a Yard Land, or the *Quartona Terræ*, but both very erroneously.

ROOT. Whatever Quantity being multiplied into itself produces a Square, and that Square again being multiplied by that first Quantity produces a Cube, &c. is called a *Root*, and is either the *Square*, *Cube*, or *Biquadrate Root*, &c. ac-

cording to the Multiplication. See *Square*, *Cube*, &c.

ROOT *of an Equation*. See *Equation*.

ROTA ARISTOTELICA, is the Consideration of a Wheel moving along a Plane, till it hath made one entire Revolution: For then will its Centre have described a Line equal to that of the Circumference of the Wheel, and so will all lesser Concentrical Circles.

ROYAL FORT. See *Fort*.

ROYAL PARAPET, *or* PARAPET *of the Rampart*, in Fortification, is a Bank about three Fathoms broad, and six Foot high, placed upon the Brink of the Rampart, towards the Country, to cover those who defend the Rampart.

RULE *of Three*, or the *Rule of Proportion*, or, as it is called from its excellent Use, the *Golden Rule*, is that which teaches to find a fourth Number, which shall have the same Proportion to one of the three Numbers given, as the others have to one another. And this is performed by multiplying the second Number by the third, and dividing the Product by the first.

This *Rule of Three* is, 1. Direct. 2. Indirect. 3. Double Rule Direct. 4. Double Rule Indirect.

1. *Rule of Three Direct* finds a fourth Number in such Proportion to the third, as the second is to the first, or as the first is to the second, so is the third to the fourth.

2. *Rule of Three Indirect*, or *Backward Rule*, is known by being contrary to the *Direct*; for whereas the former required, that more shall have more, and less less; as if 4 Yards cost 2*s.* 8 Yards will cost more than 2; because it is double to 4 Yards; and so must the Answer be double to 2*s.* that is, 4*s.*

But in this Rule more will require less, and less more; as if four Horses in 6 Days eat 10 Bushels of Oats, eight Horses will eat 10 Bushels in a lesser Number of Days, *viz.* 3.

3. The *Double Rule of Three*, both *Direct* and *Indirect*, may be comprised in one Rule, with two Operations, only observing, That the given Terms are always five, whereof three are Conditional and Antecedent, or Suppositions; the other two demand the Question, and are Consequents answering some of the former Antecedents; insomuch, that with the Answer there will be as many Consequents as Antecedents, which must match one another in the same Denomination exactly.

If the Power of any Agent be given, and it be required to find how many such Agents can produce a given Effect a in a given time; let the Power of the Agent be such, that the Effect c may be produced thereby in the time b. Then will the Number of Agents be $\frac{ad}{bc}$.

RUMB, *or* COURSE *of a Ship*, is the Angle which she makes in her Sailing with the Meridian of the Place, where she is.

Complement of the Rumb, is the Angle made with any Parallel to the Equator by the Line of the Ship's Run.

RUMB, in Navigation, is one Point of the Compass, or 11 Degrees and a quarter, *viz.* the 32d Part of the Circumference of the Horizon, or Compass-Card, which is the Representative of the Horizon.

RUMB-LINE, is a Line described by the Ship's Motion on the Surface of the Sea, steered by the Compass, making the same, or equal Angles with every Meridian.

These Rumbs are Helispherical or Spiral Lines, proceeding from the Point where we stand, winding about the Globe of the Earth, till the

they come to the Pole, where at last they lose themselves.

But in the Plane, and *Mercator*'s Charts, they are represented by straight Lines. Their Use is to shew the Bearing of any Places one from another; that is, upon what Point of the Compass any Shore or Land lies from another.

S.

SACCER. See *Saker.*

SACKS *of Earth,* used in Fortification, are made of coarse Cloth, the largest of them being about a Cubick-Foot wide, and the lesser somewhat more than half a Foot. They are serviceable upon several Occasions, more especially for making Retrenchments in haste, to place on Parapets, or the Head of the Breaches, *&c.* or to repair them when beaten down. They are of good use also when the Ground is rocky, and affords not Earth to carry on Approaches, because they can be easily brought on, and carried off: The same Bags, on occasion, are used to carry Powder in; of which they hold about fifty Pounds a-piece.

SACER. See *Saker.*

SAGITTA, a Constellation in the Northern Hemisphere, consisting of eight Stars.

SAGITTA, in Mathematicks, is the same as the Versed Sine of any Arch, and is so called by some Writers, because 'tis like a Dart or Arrow standing on the Cord of the Arch. See *Versed Sine.*

SAGGITTARIUS, is the Ninth, in the Order of the twelve Signs of the *Zodiack.*

SAILING. See *Plain,* and *Mercator*'s *Sailing.*

SAKER, a sort of Cannon, and is either extraordinary, or least Size.

SAKER EXTRAORDINARY, is four Inches Diameter at the Bore, 1800 Pounds weight, 10 Foot long, its Load five Pounds, Shot three Inches and a quarter Diameter, and something more than seven Pounds and a quarter weight; its Level-Range is 163 Paces.

SAKER *of the* LEAST SIZE, is three Inches and three quarters Bore, nine Foot long, 1500 Pounds weight, its Load near three Pounds and a half, Shot four Pounds and three quarters weight, and three Inches one quarter Diameter.

SAPPE, in Fortification, formerly signifyed the Undermining, or deep Digging with Pick-ax and Shovel at the Foot of a Work to overthrow it without Gunpowder: Now, it is used to signify a deep Trench carried far into the Ground, and descending by Steps from Top to Bottom; so that it covers the Men sideways; and to save them from Danger on the Top, they use to lay a-cross it Madriers, that is, thick Planks, or Clugs, which are Branches of Trees close bound together, and then they throw Earth over all to secure them from Fire.

When a Cover'd-Way is well defended by Musqueteers, the Besiegers must make their way down into it by Sapping.

SARRASIN, in Fortification, is a kind of Portcullice, otherwise called a *Herse,* which is hung with a Cord over the Gate of a Town or Fortress, and let fall in case of a Surprize.

SATELLITES, by Astronomers, are taken for those Planets which are continually, as it were, waiting upon, or revolving about other Planets; as the Moon may be called the *Satellite of the Earth*; and the rest of the Planets, *Satellites of the Sun:* but the Word is chiefly used for the new discovered small Planets, which make their Revolution about *Saturn* and *Jupiter.*

SATELLITES *of Jupiter,* are

four ſmall Moons or Planets moving round about the Body of *Jupiter*, as the Moon doth round our Earth: They were firſt diſcovered by *Galilæus*, by the help of the Teleſcope.

The Diſtances of theſe Satellites, *from the Body of* Jupiter, *are as follows; from the Obſervations of*

	1	2	3	4	
Mr. *Caſſini* — — — — — —	5.	8.	13.	23.	Semi-Diameter of *Jupiter*.
Mr. *Borellus* — — — — — —	5. $\frac{2}{3}$	8. $\frac{2}{3}$	14.	24. $\frac{2}{3}$	
Mr. *Townley* by the Micromet.	5. 51	8. 78	13. 47	24. 72	
Mr. *Flamſtead* by the Microm.	5. 31	8. 85	13. 98	24. 23	
Mr. *Flamſtead* by the Eclip. of *Sat.*	5. 578	8. 876	14. 159	24. 903	
From the Periodical Times	5. 578	8. 876	14. 168	24. 968	

The Periodical Times are: Of the

	Days.	Hours.	Min.	
Firſt	1	18	28 $\frac{3}{5}$	*Vid.* Newton's *Princip.* pag. 403.
Second	3	13	17 $\frac{9}{10}$	
Third	7	3	59 $\frac{3}{5}$	
Fourth	16	18	5 $\frac{1}{5}$	

Mr. *Flamſtead*, in *Philoſ. Tranſ.* N° 154. ſays, that when *Jupiter* is in a *Quartile* of the Sun, the Diſtance of the firſt Satellite from his next Limb, when it falls into his Shadow, and is eclipſed, is one Semi-Diameter of *Jupiter*; of the ſecond, two, or a whole Diameter nearly; of the third, three; of the fourth, five of his Semi-Diameters, or ſomething better, when the Parallax of the Orb is greateſt: But theſe Quantities diminiſh gradually as he approaches the Conjunction or Oppoſition of the Sun ſomewhat nearly; but not exactly in the Proportion of Sines.

SATELLITES *of Saturn.* *Anno* 1684, in the Month of *March*, Mr. *Caſſini*, by the Help of excellent Object-Glaſſes of 70, 90, 100, 136, 155, and of 220 Foot, diſcovered the two innermoſt; (that is, the firſt and ſecond) *Satellites of Saturn*.

1. The firſt Satellite he obſerved to be never diſtant from *Saturn*'s-*Ring*, above $\frac{2}{3}$ of the apparent Length of the ſame Ring; and it was found to make one Revolution about *Saturn*, in one Day, 21 Hours, and 19 Minutes; making two Conjunctions with *Saturn*, in leſs than two Days; one in the upper part of his Orb, and the other in the lower Part. It is diſtant from the Center of *Saturn* 4 $\frac{3}{8}$ of *Saturn*'s Semi-Diameter.

2. The ſecond Satellite of *Saturn* was obſerved to be $\frac{3}{4}$ of the Length of his Ring diſtant therefrom, making his Revolution about him in two Days, 17 Hours, and 43 Minutes. This is diſtant from the Center of *Saturn* 5 $\frac{3}{7}$ Semi-Diameters of that Planet.

3. From a great Number of choice Obſervations he concluded, that the Proportion of the Digreſſion of the ſecond to that of the firſt, counting both from the Centre of *Saturn*, is as 22 to 17.

4. And the Time wherein the firſt makes its Revolution, is to the Time

Time wherein the first makes its, as $24\frac{3}{4}$ to 17.

5. The third is distant from *Saturn*, eight of his Semi-Diameters, and revolves round him in almost $4\frac{3}{5}$ Days.

6. The fourth, or *Huygenian* Satellite, as 'tis called, because discovered first by Mr. *Huygens*, revolves round *Saturn*, in about 16 Days, and is distant from his Centre about 18 Semi-Diameters of *Saturn*.

7. The fifth Satellite of *Saturn* is distant from its Centre 54 Semi-Diameters of *Saturn*; and revolves round him in 79 Days. The greatest Distance between this Satellite, and the preceding, made Mr. *Huygens* suspect there may be a sixth between these two; or else, that this fifth may have other Satellites moving round him.

8. Mr. *Halley*, in *Philos. Trans.* N° 145. gives a Correction of the Theory of the Motion of the *Huygenian*, or fourth Satellite of *Saturn*, and makes the true Time of its Period to be 15 Days, 22 Hours, 41 Minutes, six Seconds; its Diurnal Motion to be 22 Degrees, 34 Minutes, 38 Seconds, 18 Thirds, and the Distance of this Satellite from the Centre of *Saturn*, to be about four Diameters of the Ring, or nine of the Globle: and the Place where it moves, to differ little or nothing from that of the Ring; that is to say, intersecting the Orb of *Saturn* with an Angle 23 Degrees and a half; so as to be nearly parallel to the Earth's Equator.

The Periodical Times of the Satellites of Saturn, *according to Mr.* Cassini *are, of the*

	Days.	Hours.	Min.
First	1	21	19
Second	2	17	43
Third	4	12	27
Fourth	15	23	15
Fifth	79	22	0

Saturn, is the highest of the Planets.

1. The Ratio of the Body of *Saturn* to our Earth, is about as 30 to 1.

2. The Perodical Time of *Saturn* about the Sun is in the Space of 30 Years, or 10950 Days.

3. The Semi-Diameter of *Saturn*'s Orbit is almost ten Times as big as that of the *Magnus Orbis*, and therefore is more than 946969690 *English* Miles.

4. According to Mr. *Cassini*, *Saturn*'s greatest Distance from the Earth is 244330, his mean Distance 210000, and his least Distance 175670 Semi-Diameters of the Earth.

5. Mr. *Huygens* found the Inclination of the Ring of *Saturn* to the *Ecliptick*, to be an Angle of 31 Degrees.

6. M. *Azout* asserts, that the remote Distance of *Saturn* from the Sun doth not hinder but that there is Light enough to see clear there, and more than in our Earth in cloudy Weather.

7. In an Observation, which Mr. *Cassini* made *June* 19. 1692. of a precise Conjunction between a fixed Star, and one of *Saturn*'s Satellites, he saith, that with his 39 Foot-Glass he could plainly see the Shadow of *Saturn*'s Globe to be in part oval upon the hinder part of his Ring. The Diameter of *Saturn* at the

the Time of this Observation, appeared to be 45 Seconds.

8. The Diameter of *Saturn* to that of the Ring, is as 4 to 9.

9 And the Diameter of the Ring seen from the Sun, would be but 50″, and therefore, the Diameter of *Saturn* seen from thence would be but 11″. As Mr. *Flamstead* found by measuring it. But Sir *Isaac Newton* thinks it ought rather to be accounted but as 10″. or 9″. because he supposes the Globe of *Saturn* to be a little dilated by the unequal Refrangibility of Light.

10. The Distance of *Saturn* from the Sun is about ten Times as great as that of our Earth from him; and therefore that Planet will not have above the 100th Part of the Influence of the Sun which we have; and consequently cannot be habitable by such Creatures as live on our Globe, unless there be some unknown Way of communicating Heat to him.

11. Dr. *Gregory*, in his *Astronomy*, makes the Semi-Diameter of the Ring of *Saturn* to that of the Planet, as 2 $\frac{1}{4}$ to 1.

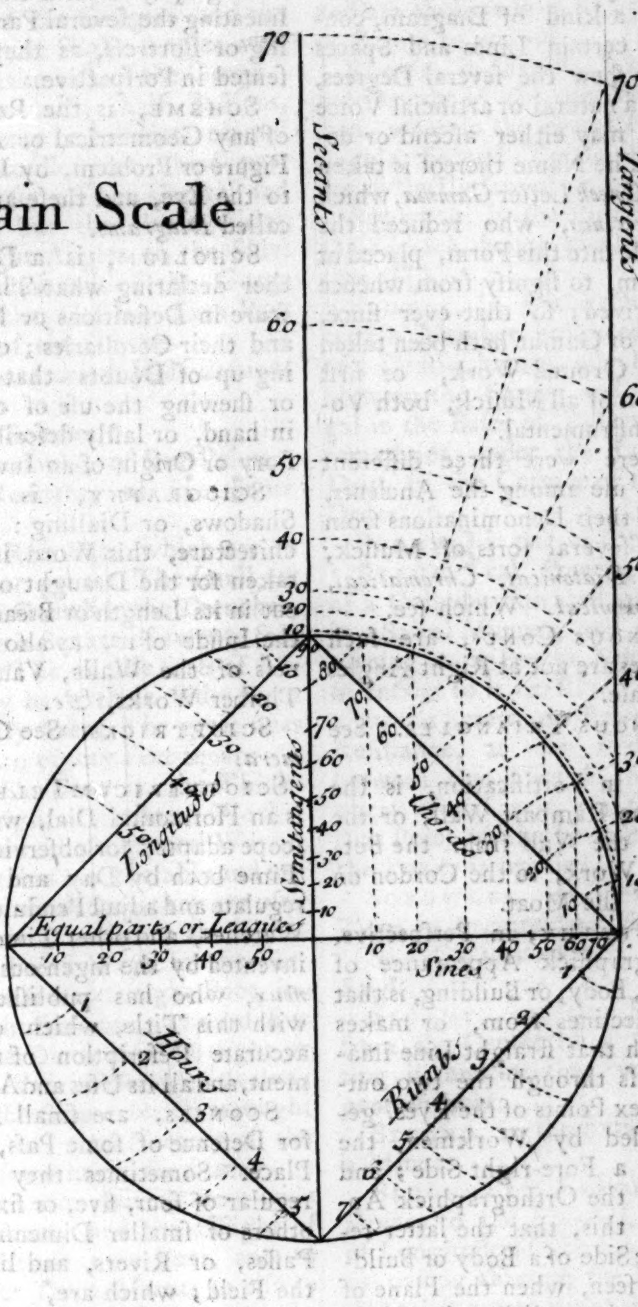
12. And the Interstice between the Planet and the Ring, is the Breadth of the Ring.

13. How the Ring of *Saturn* will appear in all Parts of the Orbit of the Planet, to an Eye placed at the Sun, or at the Earth, the same learned Astronomer shews in his *Astro. Phy. & Geometr. Lib.* IV. *Prop.* 69, 70.

SCALE, in Mathematicks, signifies any Measures or Numbers which are commonly used; or, the Degrees of any Arch of a Circle, or of such Right Lines as are divided from thence; such as Sines, Tangents, Chords, Secants, &c. drawn or plotted down upon a Ruler, for ready Use and Practice in Geometrical, or other Mathematical Operations.

The Plain Scale (for Sea-Use) has also set thereon the Scale of Chords, natural Sines, Tangents, Semi-Tangents, Secants, Rhumbs, Hours, Leagues, and Longitudes; with the Diagonal Scale on the Back-Side, and some others, according as there is Room.

Plain Scale



Secants
Tangents
Semitangents
Longitudes
Chords
Equal parts or Leagues
Sines
Hours
Rumbs

Scale *of the Gamut*, or *Musical Scale*, is a kind of Diagram, consisting of certain Lines and Spaces drawn to shew the several Degrees, whereby a natural or artificial Voice or Sound may either ascend or descend. The Name thereof is taken from the *Greek* Letter *Gamma*, which *Guido Aretinus*, who reduced the *Greek* Scale into this Form, placed at the Bottom, to signify from whence it was derived; so that ever since, this Scale or Gamut hath been taken for the Ground-Work, or first Foundation of all Musick, both Vocal and Instrumental.

But there were three different Scales in use among the Ancients, which had their Denominations from the three several sorts of Musick, *viz.* the *Diatonical*, *Chromatical*, and *Inharmonical*. Which see.

Scalenous Cones, are such whose Axes are not at Right Angles to their Base.

Scalenous Triangles. See *Triangles*.

Scarp, in Fortification, is the Foot of the Rampart-Wall, or the Sloping of the Wall from the Bottom of the Work, to the Cordon on the Side of the Moat.

Scenography, in Perspective, the Scenographick Appearance of any Figure, Body, or Building, is that Side that declines from, or makes Angles with that straight Line imagined to pass through the two outward Convex Points of the Eyes, generally called by Workmen, the Return of a Fore-right Side; and differs from the Orthographick Appearance in this, that the latter represents the Side of a Body or Building as it is seen, when the Plane of the Glass stands parallel to that Side: But Scenography represents it, as it seems, through a Glass not parallel to that Side.

In Architecture and Fortification, Scenography is the Manner of delineating the several Parts of a Building or Fortress, as they are represented in Perspective.

Scheme, is the Representation of any Geometrical or Astronomical Figure or Problem, by Lines sensibly to the Eye, and these are otherwise called *Diagrams*.

Scholium, is a Discourse either declaring what Things are obscure in Definitions or Propositions, and their Corollaries; or else clearing up of Doubts that may arise; or shewing the use of the Doctrine in hand, or lastly describing the History or Origin of an Invention.

Sciography, is the Art of Shadows, or Dialling: Also in Architecture, this Word is sometimes taken for the Draught of a Building cut in its Length or Breadth, to shew the Inside of it, as also the Thickness of the Walls, Vaults, Floors, Timber Works, *&c.*

Scioptricks. See *Obscura Camera*.

Sciothericum Telescopium, is an Horizontal Dial, with a Telescope adapted for observing the true Time both by Day and Night, to regulate and adjust Pendulum Clocks, Watches, and other Time-Keepers; invented by the ingenious Mr. *Molyneux*, who has published a Book with this Title, which contains an accurate Description of this Instrument, and all its Uses and Application.

Sconses, are small Forts built for Defence of some Pass, River, or Place. Sometimes they are made regular of four, five, or six Bastions; others of smaller Dimensions fit for Passes, or Rivers, and likewise for the Field; which are,

1. Triangles with Half-Bastions, which may be all of equal Sides, or they may be a little unequal. However it be, divide the Sides of the Triangle into two equal Parts, one of

of these three Parts will set off the Capitals, and the Gorges, and the Flanks being at Right Angles with the Sides, make half of the Gorge.

2. Squares with half Bastions, whose Sides may be betwixt 100 and 200 Foot; and let one Third part of the Side set off the Capital and the Gorges; but the Flank (which rises at Right Angles to the Side) must be but one half of the Gorge or Capital, that is, the sixth Part of the Side of the Square.

3. A Square with Half-Bastions and Tong.

4. Long Squares.

5. Star Redoubt, of four Points.

6. Star Redoubt, of five or six Points.

7. Plain Redoubts, which are either small or great: The small are fit for court Guards in the Trenches, and may be a Square of twenty foot to thirty. The middle sorts of Redoubts may have their Sides from thirty to fifty Feet: The great ones from sixty to eighty Feet square

The Profile (that is, the Thickness and Height of the Breast-Works) to be set on these several Works, and the Ditches are alterable and uncertain; for sometimes they are used in Approaches, and then the Wideness of the Breast-Work at the Bottom may be seven or eight Foot, inward Height six, and outward five Foot. The Ditch may be eight or ten Foot, and sometimes twelve: And for the Slopes to be wrought according to the Nature of the Earth; sometimes they may be made fourteen or twenty Foot wide at the Bottom, and the Height of seven, eight or nine Foot, and to have two or three Ascents to rise to the Parapet: The Ditch may be sixteen or twenty-four Foot wide, and five or six deep; and sometimes they may come near the smallest sort of Ramparts, and have a Breast-Work Cannon-proof, with a Ditch of fifty or sixty Foot wide, and are thus made to set upon Passes or Rivers to endure.

SCORE, in Musick, is the original Daught of the whole Composition, wherein the several Parts, *viz.* Treble, Second Treble, Base, *&c.* are distinctly scored or marked.

SCORPIO, is the Eighth Sign of the *Zodiack*, being usually marked thus (♏).

SCOTIA, in Architecture, is a certain Member hollowed in form of a Demi-Channel, which is placed between the Torus, and the Astragal in the Bases of Pillars; as also sometimes under the Larmier or Drip, in the Cornice of the *Dorick* Order.

SCREW } is one of the mechani-
SCRUE, } cal Powers, consisting of a Cylinder sulcated or hollowed in a Spiral Manner, and moving or turning in a Box or Nut, cut so as to answer to it exactly.

In the Screw, the Power is to the Resistance, as the said Distance between two Threads to the Periphery of a Circle, run through by that Point of the Handle to which the Power is applied.

SCROWLES, *or* VOLUTES, a Term in Architecture. See *Volutes.*

SEA-QUADRANT. See *Back-Staff.*

SECANT, is the Line drawn from the Centre of a Circle, cutting it, and meeting with a Tangent without.

SECOND, is the sixtieth Part of a Minute.

SECONDARY CIRCLES, in reference to the *Ecliptick*, or Circles of Longitude of the Stars, are such as passing through the Poles of the *Ecliptick*, are at Right Angles to the *Ecliptick*, (as the *Meridian* and Hour-Circles are to the *Equinoctial.*) By the help of these (infinitely many Circles) all Points in the Heavens are referred to the *Ecliptick*: That is,

is, any Star or Phænomenon. And if two Stars, &c. are thus referred to the ſame Point of the *Eckliptick*, they are ſaid to be in Conjunction; if in oppoſite Points, they are ſaid to be in Oppoſition: If they are referred to two Points at a Quadrant's Diſtance, they are ſaid to be in a Quartile Aſpect; if the Points differ a ſixth Part of the *Ecliptick*, the Stars are ſaid to be in a Sextile Aſpect, &c.

And, in general, all Circles which interſect one of the ſix greater Circles of the *Sphere* at Right-Angles, may be called Secondary Circles; as the Azimuths or Vertical Circles in reſpect of the Horizon, &c.

SECONDARY PLANETS, are ſuch as move round others, which they reſpect as the Centre of their Motion, though they move alſo along with the Primary Planets in the annual Orbit round the Sun; and theſe are otherwiſe called the *Satellites*, ſuch as the Moon to the Earth: And *Jupiter* hath four moving round him; as *Saturn*, according to *Caſſini*, hath five. *Mars*, *Venus* and *Mercury*, have no Secondary Planets moving round them, that have been yet diſcovered.

SECTION CONICK. See *Conick Section*.

SECTION, in Mathematicks, ſignifies the cutting of one Plane by another, or a Solid by a Plane.

The common Section of two Planes is always a Right-Line, being the Line ſuppoſed to be drawn on one Plane by the Section of the other, or by its Entrance into it.

SECTION *of a Building*, in Architecture, is underſtood of the Profile and Delineation of its Heights and Depths raiſed on a Plane; as if the Fabrick were cut aſunder to diſcover the Inſide.

SECTOR, is an Inſtrument made of Wood, Ivory, Braſs, &c. with a Point, and ſometimes a Piece to turn out to make a true Square, with Lines of Sines, Tangents, Secants, equal Parts, Rhumbs, Polygons, Hours, Latitudes, Metals, Solids, &c. and is generally uſeful in all the practical Parts of the Mathematicks, and particularly contrived for Navigation, Surveying, Aſtronomy, Dialling, Projection of the Sphere, &c. by *Gunter*, *Foſter*, *Collins*, and others. There are likewiſe Sectors for Fortification and Gunnery, by Sir *Jonas Moor*.

The great Advantage of the Sector above any Rule or Scale is, that all its Lines can be accommodated to any Radius; which is done by taking off all Diviſions parallelwiſe and not lengthwiſe. The Ground of which Practice is this, that Parallels to the Baſe of any Plain Triangle, bear the ſame Proportion to it :: as the Parts of the Legs above the Parallel do to the whole Legs.

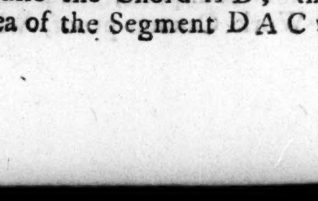
SECTOR *of a Circle*, is a mixt Triangle comprehended between two Radius's and an Arch of the Circle.

SECUNDANS, in Mathematicks, is an infinite Series of Numbers, beginning from nothing, proceeding as the Squares of Numbers in Arithmetical Progreſſion. As for Inſtance,

0, 1, 4, 9, 16, 25, 36, 49, 64, &c.

SEGMENT *of a Circle*, is a Figure contained between a Chord and an Arch of the ſame Circle.

If the Altitude AB of the Segment DAC of a Circle be biſſected in E, and the Right-Line DE be drawn,



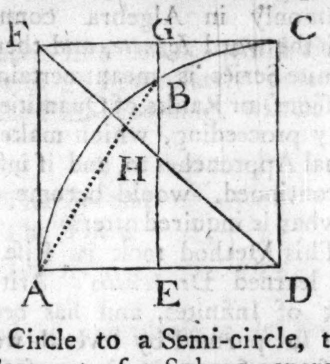
as alſo the Chord AD; then the Area of the Segment DAC will be nearly

nearly equal to $\frac{4}{5}BD+\frac{8}{15}AD\times AB$. Or, nearly equal to $\frac{8DE+2AD}{15}\times 2AB$. Or, if you take BE to AB as $\sqrt{10}$ to 5, twice the Rectangle $AB\times ED$ will be to the Area of the Segment DAC, as 3 to 2 nearly. See *Newton*'s Fluxions at the End.

SEGMENT *of a Sphere*, is a Part of it cut off by a Plane; and therefore the Base of such a Segment must always be a Circle, and its Superficies a Part of the Surface of the Sphere.

Its Solid Content is found by multiplying the Surface of the whole Sphere, by the Altitude of the Segment, and then dividing the Product by the Diameter of the Sphere, and to the Quotient adding the Area of the Base of the Segment.

If ACD be a Quadrant of a Circle, AFCD a Square, and EBCD be $\frac{1}{2}$ the Complement of a Segment



of a Circle to a Semi-circle, then the Segment of a Sphere generated by the Rotation of the Semi-Segment EBCD about AED, together with the Cone generated by the Right-angled Isosceles Triangle EHD, are equal to a Cylinder generated by the Rotation of the Oblong ECD, about ED.

If to 3 times the Square of the Semi-diameter of the Base of the Segment of a Sphere be added the Square of the Segment's Altitude, and the Sum be multiplied by the Altitude of the Segment; and this Product again by the constant Decimal .5236, the Sum will be nearly equal to the Solidity of that Segment.

The Surface of any Segment of a Sphere generated by the Rotation of the Semi-Segment ABE of a Circle, is equal to a Circle, the Radius of whose Base is the Chord AB drawn from the Vertex A to the Extremity B of the Radius of the Base of the Segment.

SEMI-BREVE, a Term in Musick. See *Notes* and *Time*.

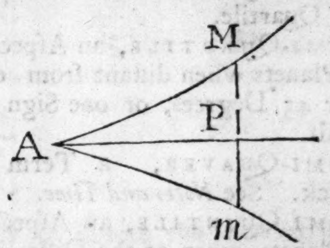
SEMI-CIRCLE, is the Figure contained between the Diameter of a Circle, and half the Circumference.

Also an Instrument for surveying, made of Brass, and divided into 180 Degrees, being half the Theodolite, is so called.

SEMI-CUBICAL *Parabola*, is a Curve as AM*m* of the second Order, or one of Sir *Isaac Newton*'s five diverging Parabola's, wherein the Cubes of the Ordinates PM are as the Squares of the Abscisses, that is, supposing *a* an invariable Quantity of a proper Magnitude, it will be $a\times\overline{AP}^2=\overline{PM}^3$, or $\overline{Pm}^3$.

The Solid generated by the Rotation of the Space APM about the Axis AP, will be $\frac{1}{4}$ of a Cylinder circumscribing it, and a Circle equal to the Surface of that Solid may be found from the Quadrature of an Hyperbolick Space.

The Length of any Arch AM of



this Curve, may be easily obtained from the Quadrature of a Space contained

contained under part of the Curve of the common Parabola, two Semi-ordinates to the Axis, and the Part of the Axis contained between them. And the Curve, may be described by a continued Motion, *viz.* by fastening the Angle of a Square, in the Vertex of a common Parabola; and then carrying the Intersection of one side of this Square and a long Ruler (which Ruler always moves perpendicular to the Axis of the Parabola) along the Curve of that Parabola. For the Intersection of that Ruler, and the other side of the Square will describe a Semicubical Parabola. Mr. *Mac-Laurin* in his *Geometr. Organica* does this without a common Parabola.

SEMI-DIAMETER, or *Radius*, is that Line that is drawn from the Centre to the Circumference of a Circle.

SEMI-DIAMETER, in *Fortification*, is two-fold, *viz.* the greater and lesser: The former being a Line composed of the Capital, and the small Semi-Diameter of the Polygon; and the other, a Line drawn to the Circumference from the Centre through the Gorges.

SEMI-DIAPASON, a Term in Musick, signifying a defective or imperfect Octave.

SEMI-DIAPENTE, in Musick, signifies an imperfect Fifth.

SEMI-DITONE, in Musick, is the lesser Third, having its Terms as six to five.

SEMI-QUADRATE, the same with Quartile.

SEMI-QUARTILE, an Aspect of the Planets when distant from each other 45 Degrees, or one Sign and an half.

SEMI-QUAVER, a Term in Musick. See *Notes and Time*.

SEMI-QUINTILE, an Aspect of the Planets, when at the Distance of 36 Degrees from one another.

SEMI-SEXTILE, an Aspect of the Planets when distant from one another 30 Degrees, or one Sign, and is noted thus, *S S*.

SEMI-TONE, a Term in Musick, of which there are two sorts, *viz.* a greater and lesser; the Inharmonical Deisis being the Difference between them.

SENSIBLE HORIZON. See *Horizon*.

SENSIBLE POINT. See *Point Sensible*.

SERPENTARIUS, a Constellation in the Northern Hemisphere, consisting of thirty Stars.

SEPTENTRIONAL SIGNS, are the first six Signs of the *Zodiack*, so called, because they decline towards the North from the Equinoctial, and are the same with *Boreal Signs*.

SERIES, properly speaking, is an orderly Process or Continuation of things one from another. 'Tis commonly in Algebra connected with the word *Infinite*, and there by Infinite Series is meant certain Progressions, or Ranks of Quantities, orderly proceeding, which make continual Approaches to, and if infinitely continued, would become equal to what is inquired after.

This Method took its Rise from the learned Dr. *Wallis*'s Arithmetick of Infinites, and has been of late so pursued by several worthy Persons of our Nation, especially the incomparable Sir *Isaac Newton*, that it is now one of the greatest Improvements of Algebra.

Every infinite Series may be summed up, if the Terms of it are expressed by a Fraction, the Factors of the Denominator of which are taken from any Arithmetical Progression, and the Numerator be a Multinomial, whose Dimensions at least are less by two than those of the Denominator.

The

The following Account of the Method *of Increments* of Mr. *Cunn's* being new, eaſy and plain, it will not be amiſs to inſert here.

LET Q be ſome Integral Quantity, equally increaſing by the conſtant Increment q, which let bear a finite Relation to Q.

Then if Q be the preſent Value of the Integral,
$Q+q$ will be the Firſt ſucceeding Value,
$Q+2q$ the Second,
$Q+3q$ the Third,
And $Q+nq$ the n^{th}.

And let theſe ſeveral ſucceſſive Values, for Eaſe and Convenience, be denoted by the ſame Q accented underneath:

Then Q will be denoted by Q

$Q+q$ by $\underset{\prime}{Q}$

$Q+2q$ by $\underset{\prime\prime}{Q}$

$Q+3q$ by $\underset{\prime\prime\prime}{Q}$

$Q+nq$ by $\underset{n}{Q}$

And in like manner whilſt Q is the preſent Value of the Integral, the Value of Q immediately preceding the preſent, which, if you pleaſe to call the Firſt Preceding, will be

$Q-q$
The Second $Q-2q$
The Third $Q-3q$
The n^{th}. $Q-nq$

And if you pleaſe to let theſe be denoted by the ſame Q accented above;

Then $Q-q$ will be denoted by $\overset{\prime}{Q}$

$Q-2q$ $\overset{\prime\prime}{Q}$

$Q-3q$ $\overset{\prime\prime\prime}{Q}$

$Q-nq$ $\overset{n}{Q}$

N. B. Dr. *B. Taylor*, and others, choſe to denote the Increments by the ſame Letters with the Integrals; only for Diſtinction ſake they point them beneath:

So

Now, if we make m to increase uniformly by the Increment 1, and find the following State m, that is, when m becomes $m+1$; or which amounts to the same Thing, multiply the preceding Supposition by $a+x$, we shall have the Product.

$$a^{m+1} + ra^m x + sa^{m-1}x^2 + ta^{m-2}x^3 + va^{m-3}x^4, \text{ \&c.}$$
$$+ 1a^m x + ra^{m-1}x^2 + sa^{m-2}x^3 + ta^{m-3}x^4, \text{ \&c.}$$

In which $\underset{\cdot}{m} = 1 = \underset{\cdot}{r}$ whence $m = r$

Also $\underset{\cdot}{s} = r = m \quad \therefore \quad s = \dfrac{\grave{m}m}{2}$

And $\underset{\cdot}{t} = s = \dfrac{\grave{m}m}{2} \quad \therefore \quad t = \dfrac{\grave{\grave{m}}\grave{m}m}{3.2}$

Likewise $\underset{\cdot}{v} = t = \dfrac{\grave{\grave{m}}\grave{m}m}{3.2} \quad \therefore \quad v = \dfrac{\grave{\grave{\grave{m}}}\grave{\grave{m}}\grave{m}m}{4.3.2.}$

Whence $\overline{a+x}|^m = a^m + ma^{m-1}x + \dfrac{\grave{m}m}{2}a^{m-2}x^2 + \dfrac{\grave{\grave{m}}\grave{m}m}{2.3.}a^{m-3}$ x^3, &c.

There are other Theorems for this Purpose, easily deduced from this: Such is this following; where A is the first Term, B the second, C the third, &c.

$$\overline{a+x}|^m = a^m + \frac{mAx}{a+x} + \frac{\frac{m+1}{2}Bx}{a+x} + \frac{\frac{m+2}{3}Cx}{a+x}, \text{ \&c.}$$

Of all the Varieties for this Purpose, every one hath some peculiar Property which the rest have not.

2. To raise the Infinitonomial to any Power indetermined m.

Suppose it to be $A + By + Cy^2 + Dy^3 + Ey^4$, &c. $=$

$$A \times 1 + \frac{B}{A}y + \frac{C}{A}y^2 + \frac{D}{A}y^3, \text{ \&c.}$$

Which call $\quad A \times 1 + by + cy^2 + dy^3 + ey^4 + fy^5$, &c.

Then for the Form of the Power, you may observe (by Induction) that the first Term will be always 1; the second, where the Index of y will be an Unit, cannot be formed by any of these Terms but the *1st* and *2d*; and that the third Term, where the Index of y is 2, can be produced only by either

either squaring the $2d$, or multiplying the $3d$ by the $1st$ Term. And the fourth, either by multiplying the $1st$ by the $4th$, the $2d$ by the $3d$, or the Cube of the $2d$; and so proceeding, taking all the possible Ways. And then you will have, if the required Power's Index be denoted by m,

$$\begin{array}{llllll} A^m \times 1 + gby & + hcy^2 & + ldy^3 & + qey^4 & & \\ & + kb^2y^2 & + nbcy^3 & + rbdy^4 & & \\ & & + pb^3y^3 & + sccy^4 & & \\ & & & + tbbcy^4 & + vb^4y^4 & \end{array}$$

Let m increase to $m + 1$, and the Power of the Infinitonomial will be,

$$\begin{array}{l|l|l|l} 1 + gby & + hcy^2 & + ldy^3 & + qe \\ \hline + by & + kb^2y^2 & + nbcy^3 & + rbd \\ & \overline{} & + pb^3y^3 & + scc \quad Y^4 \\ & + gb^2 \quad Y^2 & \overline{} & + tbbc \\ & + c & + hcb & + vb^4 \\ & & + kb^3 \quad Y^3 & \overline{} \\ & & + gbc & + ldb \\ & & + d & + nb^2c \\ & & & + pb^4 \\ & & & + hc^2 \quad Y^4 \\ & & & + kb^2c \\ & & & + gbd \\ & & & + e \end{array}$$

Here it appears, by comparing like Terms, that by is the Increment of gby, that is,

$$\underset{\cdot}{g} = 1 = \underset{\cdot}{m}. \text{ therefore } g = m.$$

And $\underset{\cdot}{h} = 1 = \underset{\cdot}{m} \quad \therefore \quad h = m$

$$\underset{\cdot}{k} = g = m \quad \therefore \quad k = \frac{\grave{m}m}{2}$$

$$\underset{\cdot}{l} = 1 = \underset{\cdot}{m} \quad \therefore \quad l = m$$

$$\underset{\cdot}{n} = h + g = m + m = 2m \quad \therefore \quad n = \frac{2\grave{m}m}{2} = \grave{m}m$$

$$\underset{\cdot}{p} = k = \frac{\grave{m}m}{2} \quad \therefore \quad p = \frac{\grave{\grave{m}}\grave{m}m}{2.\ 3.}$$

$\underset{\cdot}{q} =$

$$q = 1 = m \quad \therefore \quad q = m$$

$$r = l + g = 2m \quad \therefore \quad r = \frac{m\grave{m}}{1}$$

$$s = b = m \quad \therefore \quad s = \frac{m\grave{m}}{2}$$

$$t = n + k = m\grave{m} + \frac{m\grave{m}}{2} \quad \therefore \quad t = \frac{m\grave{m}\grave{\grave{m}}}{3} + \frac{m\grave{m}\grave{\grave{m}}}{2.\,3.}$$

$$v = p = \frac{m\grave{m}\grave{\grave{m}}}{2.\,3.} \quad \therefore \quad v = \frac{m\grave{m}\grave{\grave{m}}\grave{\grave{\grave{m}}}}{4.\,3.\,2.}$$

Now restore the Values of b, c, d, e, &c. and multiply by A^m, and restore the Values of g, h, k, &c. and it will be

$$A^m$$
$$+\frac{m}{1}A^{m-1}By$$
$$+\frac{m}{1}\times\frac{m-1}{2}A^{m-2}B^2y^2$$
$$+\frac{m}{1}A^{m-1}Cy^2$$
$$+\frac{m}{1}\times\frac{m-1}{2}\times\frac{m-2}{3}A^{m-3}B^3y^3$$
$$+\frac{m}{1}\times\frac{m-1}{1}A^{m-2}BCy^3$$
$$+\frac{m}{1}A^{m-1}Dy^3$$
$$+\frac{m}{1}\times\frac{m-1}{2}\times\frac{m-2}{3}\times\frac{m-3}{4}A^{m-4}B^4y^4$$
$$+\frac{m}{1}\times\frac{m-1}{2}\times\frac{m-2}{3}A^{m-3}B^2Cy^4$$
$$+\frac{m}{1}\times\frac{m-1}{2}A^{m-2}C^2y^4$$
$$+\frac{m}{1}\times\frac{m-1}{1}A^{m-2}BDy^4$$
$$+\frac{m}{1}A^{m-1}Ey^4$$

&c.

3. If

3. If the Terms of any Series be a, $a+x$, $a+2x$, &c. till $a+nx$, and you require the Sum of all:

Let the Term next following the last (*viz.* $a+\overline{n+1}\times x$) be called m;

then will m be the Increment of the Sum: And so $\frac{\grave{m}m}{2\underset{\cdot}{m}}+A$, the Integral of m, will be the Sum it self. But when the Term next following the last is a, then the Series is nothing. Therefore when $m=a$; then

$$\left(\frac{\grave{m}m}{2\underset{\cdot}{m}}+A,\ i.\ e.\right)\frac{a\grave{a}}{2\underset{\cdot}{a}}+A=0.$$

Whence $A=-\frac{\grave{a}a}{2\underset{\cdot}{a}}=\frac{\overline{a-x}\times a}{2\underset{\cdot}{x}}$.

Therefore the Sum sought is $\frac{\grave{m}m}{2\underset{\cdot}{m}}-\frac{\grave{a}a}{2\underset{\cdot}{a}}$.

Which, if c be the last Term, will be

$$\frac{c\underset{\prime}{c}}{2\underset{\cdot}{c}}-\frac{\grave{a}a}{2\underset{\cdot}{a}}=\frac{cca=ca\grave{a}}{2\underset{\cdot}{c}\underset{\cdot}{a}}=\frac{cc+cx-aa+ax}{2x}$$

From the former Series a, $a+x$, &c. let there be found this $a\times\overline{a+x}$, $\overline{a+x}\times\overline{a+2x}$, $\overline{a+2x}\times\overline{a+3x}$, $\overline{a+3x}\times\overline{a+4x}$, &c. till $\overline{a+nx}\times\overline{a+\overline{n+1}\,x}$: to find the Sum of all.

Then let the Term immediately following the last be $m\underset{\prime}{m}$, which is the Increment of the Sum:

Therefore the Sum is $\frac{\grave{m}m\underset{\prime}{m}}{3\underset{\cdot}{m}}+A$.

When that which immediately follows the last is $a\underset{\prime}{a}$ the Sum is = nothing

Therefore, writing $a\underset{\prime}{a}$ for $m\underset{\prime}{m}$, the Sum

$$\frac{\grave{a}a\underset{\prime}{a}}{3\underset{\cdot}{a}}+A=3 \quad\therefore\quad A=-\frac{\grave{a}a\underset{\prime}{a}}{3\underset{\cdot}{a}}$$

Consequently $\frac{\grave{m}mm'}{3\dot{m}} - \frac{\grave{a}aa'}{3\dot{a}}$ is the Sum sought:

Where if c be the last Term of the Arithmetick Series, it will be

$$\frac{\grave{c}cc'}{3\dot{c}} - \frac{\grave{a}aa'}{3\dot{a}} = \frac{c^3 + x^2a - cx^2 - a^3}{3c}.$$

Also from the same Series, *viz.* $a + x$, *&c.* let this be form'd: $a \times \overline{a+x} \times \overline{a+2x} \times \overline{a+3x}$, $\overline{a+x} \times \overline{a+2x} \times \overline{a+3x} \times \overline{a+4x}$, *&c.* till $\overline{a+nx} \times \overline{a+\overline{n+1}\,x} \times \overline{a+\overline{n+2}\,x} \times \overline{a+\overline{n+3}\,x}$.

Let the Term immediately following the last be $mm'm''m'''$, which is the Increment of the Sum;

And the Integral $\frac{\grave{m}mm'm''m'''}{5\dot{m}} + A$ is the Sum.

But when the Term next following the last is $aa'a''a'''$, the Series is 0.

Therefore $\frac{\grave{a}aa'a''a'''}{5\dot{a}} + A = 0$ ∴ $A = -\frac{\grave{a}aa'a''a'''}{5\dot{a}}$

Consequently $\frac{\grave{m}mm'm''m'''}{5\dot{m}} - \frac{\grave{a}aa'a''a'''}{5\dot{a}}$ is the Sum sought.

Or, $\frac{\overset{\prime\prime\prime\prime}{c}\overset{\prime\prime\prime}{c}\overset{\prime\prime}{c}\overset{\prime}{c}c}{5\dot{c}} - \frac{\grave{a}aa'a''a'''}{5\dot{a}}$, if c be the last Term in the Arithmetick Series.

Other Examples of putting variable Quantities into Increments.

Example 8. The Increment of $\frac{1}{n} = \frac{1}{n'} - \frac{1}{n} = \frac{n - n'}{nn'} = \frac{n - n - \dot{n}}{nn'}$

$= -\frac{\dot{n}}{nn'}$.

Example

Example 9. The Increment of $\frac{1}{n\underset{\backslash}{n}\underset{\backslash\backslash}{n}}$ is $\frac{1}{\underset{\backslash}{n}\underset{\backslash\backslash}{n}\underset{\backslash\backslash\backslash}{n}} = \frac{1}{n\underset{\backslash}{n}\underset{\backslash\backslash}{n}} =$

$$\frac{n\underset{\backslash}{n}\underset{\backslash\backslash}{n} - \underset{\backslash}{n}\underset{\backslash\backslash}{n}\underset{\backslash\backslash\backslash}{n}}{n\underset{\backslash}{n}^2\underset{\backslash\backslash}{n}^2\underset{\backslash\backslash\backslash}{n}} = \frac{n - \underset{\backslash\backslash\backslash}{n} \times \underset{\backslash}{n}\underset{\backslash\backslash}{n}}{n\underset{\backslash}{n}^2\underset{\backslash\backslash}{n}^2\underset{\backslash\backslash\backslash}{n}} = \frac{n - \underset{\backslash\backslash\backslash}{n}}{n\underset{\backslash}{n}\underset{\backslash\backslash}{n}\underset{\backslash\backslash\backslash}{n}} = \frac{n - n - 3\underset{\cdot}{n}}{n\underset{\backslash}{n}\underset{\backslash\backslash}{n}\underset{\backslash\backslash\backslash}{n}}$$

$$-\frac{3\underset{\cdot}{n}}{n\underset{\backslash}{n}\underset{\backslash\backslash}{n}\underset{\backslash\backslash\backslash}{n}}$$

Example 10. The Increment of

$$\frac{1}{z_{\alpha}\, z_{\alpha+1}\ \text{\&c. till}\ z_{\beta}} \text{ is } \frac{1}{z_{\alpha+1}\, z_{\alpha+2}\ \text{\&c. till}\ z_{\beta}\, z_{\beta+1}} - \frac{1}{z_{\overline{\alpha}}\, z_{\overline{\alpha+1}}\ \text{\&c. till}\ z_{\beta}} =$$

$$\frac{z_{\alpha}\, z_{\alpha+1}\ \text{\&c. till}\ z_{\beta} - z_{\alpha+1}\, z_{\alpha+2}\ \text{\&c. till}\ z_{\beta}\, z_{\beta+1}}{z_{\alpha}\, z_{\alpha+1}^2,\ \text{\&c. till}\ z_{\beta}^2\, z_{\beta+1}} = \frac{\overline{z_{\alpha} - z_{\beta+1}} \times z_{\alpha+1}\ \text{\&c.}\ z_{\beta}}{z_{\alpha}\, z_{\alpha+1}^2\ \text{\&c. till}\ z_{\beta}^2\, z_{\beta+1}}$$

$$= \frac{z_{\alpha} - z_{\beta+1}}{z_{\overline{\alpha}}\, z_{\overline{\alpha+1}}\ \text{\&c. till}\ z_{\beta}\, z_{\beta+1}} = \frac{z + \alpha\underset{\cdot}{z} - z - \overline{\beta+1}\,\underset{\cdot}{z}}{z_{\alpha},\ \text{\&c. till}\ z_{\beta+1}} = -\frac{\overline{\beta + 1 - \alpha} \times \underset{\cdot}{z}}{z_{\alpha},\ \text{\&c. till}\ z_{\beta+1}}.$$

Therefore to put any successive Values, dividing Unity of a flowing Quantity into Increments, multiply the Expression by the Number of the Factors into the constant Increment of the variable Quantity: Then divide by that Value of the variable Quantity which next succeeds the last which is given, and change the Sign: So you will have the Increment.

Cor. Hence also it naturally follows, that the Integral of any such Increment will be had thus:

Change the Sign, multiply by the last given Value of the variable Quantity, and divide by the new Number of Factors into the constant Increment, and you will have the Integral.

Example 11. The Increment of any Power nn is $\underset{\backslash}{n}\underset{\backslash}{n} - nn = 2n\underset{\cdot}{n} + \underset{\cdot}{n}\underset{\cdot}{n}$.

Example 12. And the Increment of nnn is $\underset{\backslash}{n}\underset{\backslash}{n}\underset{\backslash}{n} - nnn = 3n^2\underset{\cdot}{n} + 3n\underset{\cdot}{n}^2 + \underset{\cdot}{n}^3$.

Example 13. In like manner the Increment of

$(1\,z^{m} + (2\,z^{m-1} + (3\,z^{m+2}$, &c. is

$(1\,\grave{z}^{m} + (2\,\grave{z}^{m-1} + (3\,\grave{z}^{m-2}$, &c. $-(1\,z^{m} - (2\,z^{m-1} - (3\,z^{m-2}$, &c.

$$= (1 \times m z^{m-1}\dot{z} + \frac{m\grave{m}}{2} z^{m-2}\dot{z}^{2} + \frac{m\grave{m}\grave{\grave{m}}}{2.3} z^{m-3}\dot{z}^{3}, \text{\&c.}$$

$$+ (2 \times \qquad \grave{m} z^{m-2}\dot{z} + \frac{\grave{m}\grave{\grave{m}}}{2} z^{m+3}\dot{z}^{2}, \text{\&c.}$$

$$+ (3 \times \qquad \grave{\grave{m}} z^{m-3}\dot{z}^{2}, \text{\&c.}$$

$$+ \text{\&c.} \times \qquad \text{\&c.}$$

From these Examples it is evident, that always the Index of the highest Power of the variable Quantity in the Increment is less by an Unit than the Index of the highest Power of the Integral; and that the other succeeding Terms descend as the Binomial Theorem for raising integral Powers; and consequently, the Form of the Integral of any Power is known.

Wherefore, if it be required to find the Integral of

$(1\,z^{m} + (2\,z^{m-1} + (3\,z^{m-2} + (4\,z^{m-3}$, &c.

we may with Safety put it

$$\alpha z^{m} + \beta z^{\grave{m}} + \gamma z^{\grave{\grave{m}}} + \delta z^{\grave{\grave{\grave{m}}}}\ \varepsilon z^{\grave{\grave{\grave{\grave{m}}}}}, \text{\&c.}$$

where m's Increment is an Unit. And then to determine the Coefficients, α, β, γ, &c. we have

$$(1\,z^{m} + (2\,z^{\grave{m}} + (3\,z^{\grave{\grave{m}}} + (4\,z^{\grave{\grave{\grave{m}}}}, \text{\&c.}$$

$$= \alpha \times m z^{m}\dot{z} + \frac{m\grave{m}}{2} z^{\grave{m}}\dot{z}^{2} + \frac{m\grave{m}\grave{\grave{m}}}{2.3} z^{\grave{\grave{m}}}\dot{z}^{3} + \frac{m\grave{m}\grave{\grave{m}}\grave{\grave{\grave{m}}}}{2.3.4} z^{\grave{\grave{\grave{m}}}}\dot{z}^{4}, \text{\&c.}$$

$$+ \beta \times \qquad m z^{\grave{m}}\dot{z}^{2} + \frac{m\grave{m}}{2} z^{\grave{\grave{m}}}\dot{z}^{2} + \frac{m\grave{m}\grave{\grave{m}}}{2.3} z^{\grave{\grave{\grave{m}}}}\dot{z}^{3}, \text{\&c.}$$

$$+ \gamma \times \qquad \grave{m} z^{\grave{\grave{m}}}\dot{z} + \frac{\grave{m}\grave{\grave{m}}}{2} z^{\grave{\grave{\grave{m}}}} z^{2}, \text{\&c.}$$

$$+ \delta \times \qquad m z^{\grave{\grave{\grave{m}}}}\dot{z}, \text{\&c.}$$

There-

Therefore

$$\alpha = \frac{(1}{\grave{m}} \times z^{-1}$$

$$\beta = \overline{\frac{(2}{m} - \frac{(1}{\grave{m}} \times \frac{\grave{m}}{2}} \times z^{0}$$

$$\gamma = \overline{\frac{(3}{\grave{m}} - \frac{(1}{\grave{m}} \times \frac{m\,\grave{m}}{2.\,3} - \frac{\beta\,m}{2}} \times z^{1}$$

$$\delta = \overline{\frac{(4}{\ddot{m}} - \frac{(1}{\grave{m}} \times \frac{m\,\grave{m}\,\grave{m}}{2.\,3.\,4} - \frac{\beta\,m\,\acute{m}}{2.\,3} - \frac{\gamma\,\grave{m}}{2}} \times z^{2}$$

$$\varepsilon = \frac{(5}{\dddot{m}} - \frac{(1}{\grave{m}} \times \frac{m\,\grave{m}\,\grave{m}\,\ddot{m}}{2.\,3.\,4.\,5} - \frac{\beta\,m\,\grave{m}\,\ddot{m}}{2.\,3.\,4} - \frac{\gamma\,\grave{m}\,\ddot{m}}{2.\,3.} - \frac{\delta\,\dddot{m}}{2} \times z^{3}$$

&c.

But if α, β, γ, &c. denote the Coefficients, exclusive of the Powers of z,

$$\alpha = \frac{(1}{\grave{m}}$$

$$\beta = \frac{(2}{m} - \overline{\frac{(1}{m} \times \frac{\grave{m}}{2}}$$

$$\gamma = \frac{(3}{\grave{m}} - \overline{\frac{(1}{\grave{m}} \times \frac{\grave{m}}{3} + \beta \times \frac{m}{2}}$$

$$\delta = \frac{(4}{\ddot{m}} - \overline{\frac{(1}{\grave{m}} \times \frac{\grave{m}}{4} \times \frac{m}{3} \times \gamma \times \frac{\grave{m}}{2}}$$

$$\varepsilon = \frac{(5}{\dddot{m}} - \frac{(1}{\grave{m}} \times \frac{\grave{m}}{5} + \beta \times \frac{m}{4} \times \gamma \times \frac{\grave{m}}{3} + \delta \times \frac{\ddot{m}}{2}$$

&c.

Therefore if n denotes the Order of the Terms, the first will be

$$\frac{(^{1}}{\grave{m}}\,\grave{z}\,\dot{z}^{m-1}$$

and either of the following Terms will be

$$\frac{(^{n}}{m+2-n} - \frac{(}{n} + \beta\times\frac{m}{\grave{n}} + \gamma\times\frac{\grave{m}}{\grave{\grave{n}}} + \delta\times\frac{\grave{\grave{m}}}{\grave{\grave{\grave{n}}}}\ \&c. \times z^{m+2-n-}\ .\ \dot{z}^{n-2}$$

In which Theorem we go on till a Value of $n=2$, and the Number of the Terms will be $=m+1$.

Hence, if there be a Series of Cubes whose Roots are in an Arithmetical Progression, and z^3 be put for the Term which immediately follows the last; to sum up such a Series, we must find the Integral of z^3. In which Case $m=3$, $(^1=1$, and all the following Values of C, are nothings. Therefore

The first Term

$$\frac{(^{1}}{\grave{m}}\,\grave{z}\,\dot{z}^{m-1} = \tfrac{1}{4}z^4\,\dot{z}^{-1}$$

The second Term

$$\frac{(^{n}}{m+2-n} - \frac{(}{n}\times z^{m+2-n}\,\dot{z}^{n-2} = 0 = \tfrac{1}{2}\times z^3$$

The third Term

$$\overline{\overline{\frac{(^{n}}{m+2-n} - \frac{(}{n} + \beta\times\frac{m}{\grave{n}}}}\times z^{m+2-n}\,\dot{z}^{n-2} = 0 - \tfrac{1}{3} - \tfrac{1}{2}\times$$

$$\tfrac{3}{2}\times z^2\,\dot{z} = +\tfrac{1}{4}z^2\,\dot{z}$$

The fourth Term

$$\overline{\overline{\overline{\frac{(^{n}}{m+2-n} - \frac{(}{n} + \beta\times\frac{m}{\grave{n}} + \gamma\times + \frac{m}{\grave{\grave{n}}}}}}\times z^{m+2-n}\,\dot{z}^{n-2} =$$

$$0 - \tfrac{1}{4} - \tfrac{1}{2}\times\tfrac{3}{3} + \tfrac{1}{4}\times\tfrac{2}{2}\times z\,\dot{z}^{2} = 0.$$

Therefore the Integral is $\frac{1}{4}z^4\,\dot{z}^{-1} - \frac{1}{2}z^3 + \frac{1}{4}z^2\,.\,\dot{z} + A.$

But when a, the first Term in the Arithmetical Progression, is that which immediately follows the last, the Sum is nothing.

There-

Therefore $\frac{1}{4}a^4 \underset{\cdot}{z}^{-1} - \frac{1}{2}a^3 + \frac{1}{4}a^2 \underset{\cdot}{z} + A = 0.$

Whence $A = -\frac{1}{4}a^4 \underset{\cdot}{z}^{-1} + \frac{1}{2}a^3 - \frac{1}{2}a^2 \underset{\cdot}{z}$

Therefore the Sum sought is,

$$\frac{1}{4}z^4 \underset{\cdot}{z}^{-1} - \frac{1}{2}z^3 + \frac{1}{4}z^2 \underset{\cdot}{z} - \frac{1}{4}a^4 \underset{\cdot}{z}^{-1} + \frac{1}{2}a^3 - \frac{1}{4}a^2 \underset{\cdot}{z} =$$

$$\frac{1}{4}z^2 \underset{\cdot}{z}^{-1} \times \overline{z-\underset{\cdot}{z}}\Big| - \frac{1}{4}a^2 \underset{\cdot}{z}^{-1} \times \overline{a-\underset{\cdot}{z}}\Big|^2 = \frac{\overline{z \times \overline{z-\underset{\cdot}{z}}}\Big|^2 - \overline{a \times \overline{a-\underset{\cdot}{z}}}\Big|^2}{4\underset{\cdot}{z}}$$

Serpentine Line, the ſame with Spiral; which ſee.

Sesquialter, in Muſic. See *Time*.

SesquialteralProportion, is when any Number or Quantity contains another once and an half; and the Number ſo contained in the greater is ſaid to be to it in ſubſeſquialteral Proportion.

Sesquiquadrate, an Aſpect or Poſition of the Planets, when they are at the Diſtance of four Signs and an half, or 135 Degrees from each other.

Sesquiquintile, an Aſpect of the Planets, when 102 Degrees diſtant from each other.

Sesquitertional Proportion, is when any Number or Quantity contains another once and one Third.

Sexagenary Tables, were Tables contrived (formerly) of Parts Proportional; where, by Inſpection, you may find the Product of two Sexagenaries to be multiplied, or the Quotient of two that are to be divided by one another, &c.

Sexagesimal Fractions, or *Sexagenaries*, are ſuch as have always 60 for their Denominators: There were antiently no others uſed in Aſtronomical Operations; and they are ſtill retained in many Caſes, though Decimal Arithmetick begins to grow in uſe now in Aſtronomical Calculations.

Sexangle, in Geometry, is a Figure conſiſting of ſix Angles.

Sextans, is the ſixth Part of any Thing: Thus, there is an Aſtronomical Inſtrument called a Sextant, as being the 6th Part of a Circle. This hath a graduated Limb, and is uſed like a Quadrant.

Sextile, the Poſition or Aſpect of the Planets, when at 60 Degrees diſtance, or at the Diſtance of two Signs from one another; and is marked thus ✱

Shouldering, in Fortification, is a Retrenchment oppoſed to the Enemies, or a Work caſt up for Defence on one ſide, whether it be made of Heaps of Earth caſt up, or of Gabions and Faſcines. A Shouldering alſo is a ſquare Orillon ſometimes made in the Baſtions on the Flank near the Shoulder, to cover the Cannon of a Caſemate. Again, it is taken for a Demi-Baſtion, or Work conſiſting of one Face, and one Flank, which ends in a Point at the Head of a Horn-work or Crown-work: Neither is it to be underſtood only of a ſmall Flank added to the ſides of the Hornwork, to

defend them when they are too long, but alſo to the Redoubts which are raiſed on a ſtrait Line.

SIDEREAL YEAR. See *Solar Year*.

SILLON, in Fortification, is an Elevation of Earth, made in the Middle of a Moat, to fortify it when too broad: It is otherwiſe called *Envelope*, which is the more common Name.

SIMILAR, in Geometry, is the ſame as *like*.

SIMILAR ARCHES *of a Circle*, are ſuch as are like Parts of their whole Circumferences.

SIMILAR BODIES, in natural Philoſophy, are called ſuch as have their Particles of the ſame Kind and Nature one with another.

SIMILAR *Plane Numbers*, are thoſe Numbers which may be ranged into the Form of Similar Rectangles: That is, into Rectangles whoſe Sides are proportional, ſuch are 12 and 48; for the Sides of 12 are 6 and 2. and the Sides of 48 are 12 and 4. But 6. 2 : : 12. 4. and therefore thoſe Numbers are Similar.

SIMILAR POLYGONS, are ſuch as have their Angles ſeverally equal, and the Sides about thoſe Angles proportional.

SIMILAR RECTANGLES, are thoſe which have their Sides about the equal Angles proportional.

1. All Squares are Similar Rectangles.

2. All Similar Rectangles are to each other as the Squares of their homologous Sides.

SIMILAR *Right-lin'd Figures*, are ſuch as have equal Angles, and the Sides about thoſe equal Angles proportional.

SIMILAR SEGMENTS *of a Circle*, are ſuch as contain equal Angles.

SIMILAR CURVES. Two Segments of two Curves are called ſimilar, if any Right-lined Figure, being inſcribed within one of them, we can inſcribe always a ſimilar Right-lined Figure in the other.

SIMILAR CONIC SECTIONS: Two Conic Sections are ſaid to be ſimilar, when any Segment being taken in the one, we can aſſign always a ſimilar Segment in the other.

SIMILAR DIAMETERS *of two Conic Sections*. The Diameters in two Conic Sections are ſaid to be ſimilar, when they make the ſame Angles with their Ordinates.

SIMILAR SOLIDS, are ſuch that are contained under equal Numbers of ſimilar Planes, alike ſituated.

SIMILAR TRIANGLES, are ſuch as have all their three Angles reſpectively equal to one another.

1. All ſimilar Triangles have the Sides about their equal Angles proportional.

2. All ſimilar Triangles are to one another, as the Squares of their homologous Sides.

SIMPLE FLANK. See *Flank*.

SIMPLE PROBLEM, in Mathematicks. See *Linear one*.

SIMPLE QUANTITIES, in Algebra, are ſuch as have but one Sign, whether poſitive or negative: Thus, $2a$, and $3b$, are ſimple Quantities.

But $a+b$, and $+d-c+b$ are compound ones.

SIMPLE TENAILLE. See *Tenaille*.

SINE, or *Right Sine*, is a Right Line drawn from one End of an Arch, perpendicularly upon the Diameter drawn from the other End of that Arch; or it is half the Chord of twice the Arch.

If the Radius be $=1$, then the Length of the Arch of a Quadrant will be 1.57070, &c. and the Square of it is 2.4694, &c. Now if this Square be divided by the Square of a Number expreſſing the Ratio of 90 Degrees to any given Angle, as A, and the Quotient be called z, three or four Terms of this Series

1—

$1 - \frac{z}{2} + \frac{zz}{24} - \frac{z^3}{20} + \frac{z^4}{40320}$, &c. will give the Cosine of the Angle A.

SINE COMPLEMENT. See *Complement*.

SINGLE, or *Simple Eccentricity*. See *Eccentricity*.

SINICAL QUADRANT is made of Brass or Wood, with Lines drawn from each side intersecting one another with an Index, divided by Sines, also with ninety Degrees on the Limb, and two Sights to the Edge, to take the Altitude of the Sun. Sometimes instead of Sines, 'tis divided all into equal Parts; and is used by Seamen, to solve by Inspection any Problem of Plain-sailing.

SIPHON, a Glass or Metalline crooked Pipe, Tube, or Cane. See *Syphon*.

SIRIUS, the Dog-Star, a bright Star of the first Magnitude in the Constellation *Canis Major*. Its Longitude is 99 Degrees, 47 Minutes, Latitude 39 Degrees 32 Minutes.

SLIDING Rules, or *Scales*, are Instruments to be used without Compasses, in Gauging, Measuring, &c. having their Lines fitted so, as to answer Proportions by Inspection; they are very ingeniously contrived and applied by *Gunter*, *Partridge*, *Cogshall*, *Everard*, *Hunt*, and others, who have written particular Treatises about their Use and Application.

SOLAR COMET. See *Discus*.

SOLAR CYCLE. See *Cycle of the Sun*.

SOLAR SPOTS. See *Spots of the Sun*.

SOLAR YEAR, is either *Tropical* or *Sidereal*.

Tropical Year, is that Space of Time, wherein the Sun returns again to the same Equinoctial or Solsticial Point, which is always equal to 365 Days, five Hours, and about 55 Minutes.

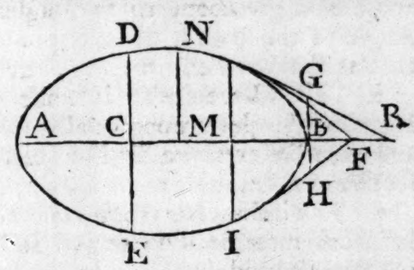
The *Sidereal Year*, is the Space wherein the Sun comes back to any particular fixed Star, which is about 366 Days, eight Hours, and nine Minutes.

SOLID ANGLE, is an Angle made by the meeting of three or more Planes, and those joining in a Point, like the Point of a Diamond well cut.

SOLID BASTION. See *Bastion*.

SOLID, in Geometry, is the third Species of Magnitude, having three Dimensions, Length, Breadth, and Thickness, and is frequently used in the same Sense with Body; it may be conceived to be formed by the direct Motion, or the Revolution of any Superficies, of what Nature or Figure soever.

SOLID *of least Resistance*. Sir *Isaac Newton*, in his *Principia*, shews, that if there be a Curve-Figure, as DNFB, of such a Nature, as that from any Point, as *N*, taken in its Circumference, a Perpendicular NM be let fall to the Axis AB: And if, from a given Point, as G, the Right Line GR, be drawn parallel to a Tangent to



the Curve in that Point N: And also, if the Axis being produced, till GR cut it, it will then be as

$$MN : GR :: GR^3 : 4BG \times GR.$$

Then the Solid, which may be generated by the Revolution of this Curve round its Axis AB, when moved most swiftly in a rare and elastick Medium, shall meet with less

less Resistance from the Medium, than any Circular Solid whatsoever, described after the same Manner, and whose Length and Breadth are the same as that.

As Sir *Isaac Newton* did not give a Demonstration of this famous Theorem, several have done it for him; amongst which, Mr. *Facio*'s is a very uncommon one, altho' ingenious enough. Mr. *Bernoulli* also has done it in the *Acta Eruditorum*, A. 1699. p. 514. And so has the Marquis *de l'Hospital* in the *French* Memoirs of the Royal Academy of *Paris*. See my Translation of this Author's *Infiniment Petit*.

Solid Numbers, are those which arise from the Multiplication of a plain Number, by any other whatsoever; as 18 is a Solid Number made of 6, (which is Plane) multiplied by 3; or of 9 multiplied by 2.

Solid Place. See *Solid Locus*.

Solid Problem, in Mathematicks, is one which cannot be geometrically solved, unless by the Intersection of a Circle, and a Conick-Section; or by the Intersection of two other Conick-Sections besides the Circle.

1. As to describe an *Isosceles* Triangle on a given Right Line, whose Angle at the Base shall be triple to that at the Vertex.

2. This will help to inscribe a Regular Heptagon, in a given Circle; and may be resolved by the Intersection of a Parabola and a Circle.

3. The following Problem also helps to inscribe a Nonagon in a Circle; and may be solved by the Intersection of a Parabola, and an Hyperbola between its Asymptotes, *viz.*

4. To describe an *Isosceles* Triangle, whose Angle at the Base shall be quadruple of that at the Vertex.

5. And such a Problem as this hath four Solutions, and no more; because two Conick Sections can cut one another but in four Points. How all such Problems are constructed, Mr. *Halley* shews in *Philos. Transact.* N° 188.

Solidity, (see *Firmness*) is a Quality of a Natural Body contrary to Fluidity, and appears to consist in the Parts of the Body's being interwoven and intangled one with another, so that they cannot diffuse themselves several ways, as Fluid Bodies can.

Solstice, is the time when the Sun, entering the Tropical Points, is got furthest from the Equator, and before he returns back towards it, in the same Parallel, and scarce making any other Lines than perfect Circles, so small is its Progress.

These Solstices are two:

1. Æstival, or Summer Solstice, when the Sun enters *Cancer*, *June* 11, making the longest Day, and the shortest Night.

2. And the Hyemal, or Winter Solstice, *December* 11, when he enters *Capricorn*, the Nights being then at the longest, and the Days at the shortest, that is, in Northern Regions; for under the *Equator* there is no Variation, but a continual Equinox; and in the Southern Parts, the Sun's Entrance into *Capricorn* makes the longest Day, and into *Cancer*, the longest Night.

Solution, in Mathematicks, is the Answering of any Question, or the Resolution of any Problem.

Sound, seems to be produced by the subtiler and more ætherial Parts of the Air, being formed and modified into a great many small Masses or Contextures, exactly similar in Figure; which Contextures are made by the Collision and peculiar Motion of the sonorous Body, and flying off from it, are diffused all round in the Medium, and there do affect the Organ of our Ear in one and the same Manner.

Sound also appears not to be produced in the Air so much by the Swiftness, as by the very frequent Reper-

Repercussions, and reciprocal Shakings of the sonorous Body.

Sir *Isaac Newton* demonstrates, (*Prop.* 43. *Lib.* 2. *of his Principles,*) that Sounds, because they arise from the tremulous Motion of Bodies, are nothing else but the Propagation of the Pulse of the Air: And this, he saith, is confirmed by those great Tremors that strong and grave Sounds excite in Bodies round about, as the Ringing of Bells, Noise of Cannon, *&c.*

And in other Places he concludes, that Sounds do not consist in the Motion of any Æther, or finer Air, but in the Agitation of the whole common Air; because he found by Experiments, that the Motion of Sound depended on the Density of the whole Air.

He found by good Experiments, that a Sound moves 968 Foot, *English*, in a Second of Time, supposing the Air by the Pulse which causes Sound, to be in a Motion, like that of Water, when its Waves roll: He calculates the Breadth of the Pulse, or the Distance between Wave and Wave, to be in the Sounds of all open Pipes double the Length of those Pipes; which he grounds on an Experiment of Father *Mersennus*, in his *Harmonics*, that an extended String made 104 Vibrations in a Second, when it was an unisone with the C faut Pipe of an Organ, whose Length was four Foot open, and two Foot stopped.

Why the Sound ceases always with the Motion of the sonorous Body, and why they reach the Ear equally soon, when far off or near, he shews in *Prop.* 48. *Cor.* Where he proves, that the Number of the Pulses propagated, is always the very same with the Number of the Vibrations of the tremulous Body, and that they are not by any means multiplied as they go from it.

The following Properties have been observed of Sound; in many of which there is a near Relation between it and Light: For,

1. As Light acquaints the Eye with the different Qualities, Magnitudes, and Figures of Bodies, so Sound, in like manner, informs the Ear of many of the same Things in the sonorous Body.

2. As Light presently vanishes on the Removal, or total Eclipse of the Radiating Body, so a Sound perishes as soon as the Undulation of the Air ceases, which Motion both produces and preserveth all Sounds.

3. The Diffusion of Sound from the sonorous Body is spherical, like the Radiation of Light from its Centre.

4. A great Sound drowns a less, as a greater Light eclipses a less.

5. Too great, loud, or shrill a Sound is offensive and injurious to the Ear, as too great and bright a Light is to the Eye.

6. Sound also (like Light) moves sensibly from Place to Place, though nothing near so swift as Light: It is reflected like Light from all hard Bodies; it is hindered and refracted by passing through a denser Medium. But it differs from Light in this, That whereas Light is always propagated in Right-Lines, the Motion of Sound is almost always curvilineal.

7. Sound also differs much from Light in this, That it is very much weakened by Winds, and such-like Motions of the Air, which yet have no Effect on Light: For *Mersennus* computes, that the Diameter of the Sphere of a Sound heard against the Wind is near a third Part less, than when coming with the Wind.

8. A very small Quantity of Body serves to reflect the Rays of Light; as we perceive manifestly in small Pieces of Looking-Glasses, *&c.* But here appears to be necessary a Body of much larger Dimensions to return a Sound, or make an Echo.

9. As to the Reflections of Sounds, 'tis observed, that if one stands near the reflecting Body, and the Sound be not very far off, though an Echo be produced, yet it cannot be heard; because the Direct and Reflex Sound enter the Ear almost at the same time: But then the Sound appears to be stronger than ordinary, and lasts longer, especially when the Reflection is made from divers Bodies at once; as from Arches and vaulted Rooms, from whence the confused Sound of such-like Places arises.

And from hence probably may be deduced the Reason, why Concave Bodies are (*cæteris paribus*) fittest to produce great and clear Sounds, such as Bells, *&c.* For in such Bodies the Sound is very swiftly and very often reflected from side to side, and from one part of the Cavity to another, and the Bell hanging at liberty, this produces great Tremblings and Shakings of the whole Concave Body, which occasions the Sound to continue till they cease and are quiet.

10. There is one Phænomenon, *viz.* that Sounds great or small, with the Wind, or against it, from the same Distance, come to the Ear at the same time.

Dr. *Holder*, in his Book of the *Natural Grounds and Principles of Harmony*, says, That if the tremulous Motion which causeth Sound be uniform, then it produces a musical Note or Sound: But if it be difform, then it produces a Noise.

The *Florentine* Academicks found a Sound to move one of their Miles (*viz.* 3000 *Braccia*, or 5925 Foot) in five Seconds of Time: Therefore, according to them, it moves 1185 Foot in one Second.

But Sir *Isaac Newton* found it to move but 968 Foot in one Second.

11. If the Air be agitated in any Manner, there arises a Motion analogous to the Motion of a Wave on the Surface of Water, which is called a *Wave of Air*.

12. And the Motion of these Waves is the Motion of a Sphere expanding itself in the same Manner as the Waves move circularly upon the Surface of the Water.

13. While a Wave moves in the Air, wherever it passes, the Particles are removed from their Place, and return to it, running through a very short Space in going and coming.

14. Wherever the neighbouring Particles are not equally distant, the Motion arising from Elasticity causes the less distant Particles to move towards those that are most distant.

15. Therefore, the Motion of the tremoulous Body, by which the Air is agitated, ceasing, there are new Waves generated.

16. Waves, whether the Air be more or less agitated, are equally swift.

17. Waves, whether equal or any Way unequal, move with the same Velocity.

18. In Waves, the Squares of their Celerities are inversly as the Densities.

19. When the Density remains the same, but the Elasticity is changed, the Squares of the Celerities of the Waves are as the Degrees of the Elasticity.

20. If the Elasticity and the Density differ, the Squares of the Velocities of the Waves will be in a Ratio compounded of the direct Ratio of the Elasticity, and the inverse Ratio of the Density.

21. If the Density and the Elasticity increase or decrease in the same Ratio, the Celerity of the Waves will not be changed.

22. Therefore, from the changed Height of the Pillar of *Mercury*, which is sustained in a Tube void of Air by the Pressure of the Atmosphere, we must not judge the Celerity of the Waves to be changed.

23. For the Waves are moved with the ſame Celerity in the Top of a Mountain, as in a Valley.

24. The Waves move faſter in Summer than in Winter.

25. By determining the Height of the Atmoſphere, ſuppoſing it every where equally denſe with the Air near the Earth, the Velocity of the Waves will be the ſame as a Body could acquire in falling from half that Height.

26. The Motion of Waves in the Air produces Sound.

27. A Body that is ſtruck, continues to give a Sound ſome time after the Blow.

28. The Celerity of the Sound is the ſame as the Celerity of the Waves, which ſtrike the Ear.

29. The Celerity of Sound is equable; yet in going through a great Space, it is ſometimes accelerated or retarded.

30. The Celerity of Sound does not much differ, whether it goes with the Wind, or againſt it.

31. Therefore, Sound may be heard at a greater or ſmaller diſtance, according to the Direction of the Wind.

32. *Cæteris paribus*, the Intenſity of Sound is as the Space run through by the Particles in their going and coming.

33. Therefore, *cæteris paribus*, the Intenſity of Sound is as the Weight by which the Air is compreſſed.

34. If all things remain as before, and the Elaſticity be increaſed, the Intenſity of Sound is directly as the Square Root of the Elaſticity, and inverſely as the Elaſticity itſelf.

35. The Intenſity of Sound is leſs in Summer than in Winter; yet in Summer, Bodies do more eaſily tranſmit Sound.

36. The Intenſity of Sound, conſidered in general, is in a compound Ratio of the Space run through by the Particles, in their going backward and forward, of the Weight compreſſing the Air; and laſtly, of the inverſe Ratio of the Square Root of the Elaſticity.

37. And the Degrees of the Sharpneſs of different Sounds are to one another, as the Number of the Waves which are produced in the Air at the ſame time.

38. A Tone does not depend upon the Intenſity of the Sound, and an agitated Cord gives the ſame Sound, whether it vibrates through a greater or a leſs Space.

39. Concords ariſe from the Agreement between the different Motions in the Air, which affect the auditory Nerves at the ſame time.

40. *Cæteris paribus*, if the Lengths of two Cords are as the Number of Returns in a Conſonance, you will have the Conſonance between the Sounds which the Strings produce.

41. And generally ſuppoſing any Cords of the ſame kind, if the Ratio be compounded of the direct Ratio of the Lengths and of the Diameters, and the inverſe Ratio of the Square-Roots of the Tenſions, (be the Ratio between the Numbers of the Vibrations performed in the ſame time in any Conſonance whatever,) you will have that Conſonance by the Agitation of thoſe Cords.

42. An agitated String will communicate Motion to another, which performs two or three Vibrations, whilſt the firſt performs but one.

Sound, in Geography, is any great Indraught of the Sea, between two Headlands, where there is no Paſſage through.

South Direct Dials. See *Prime Verticals*.

Southern Signs. See *Auſtral Signs*.

Space, if conſidered barely in Length between any two Beings, is the ſame Idea that we have of Diſtance; but if it be conſidered in Length, Breadth and Thickneſs, it is properly called Capacity; and when

when considered between the Extremities of Matter, which fills the Capacity of Space with something solid, tangible and moveable, or with Body, it is then called Extension; so that Extension is an Idea belonging to Body only. But Space, in a general Signification, is the same thing with Distance, considered every way, whether there be any solid Matter in it or not.

Space, therefore, is either Absolute or Relative.

Absolute Space, considered in its own Nature, and without regard to any thing external, always remains the same, and is immoveable; but Relative Space is that moveable Dimension or Measure of the former, which our Senses define by its Positions to Bodies within it: And this the Vulgar use for immoveable Space.

Relative Space, in Magnitude and Figure, is always the same with Absolute, but 'tis not necessary it should be so numerically. Thus, if you suppose a Ship to be indeed in absolute Rest, then the Places of all things within her will be the same absolutely and relatively, and nothing will change its Place. But then suppose a Ship under Sail, or in Motion, and she will continually pass through new Parts of absolute Space; but all things on board considered relatively, in respect to the Ship, may be notwithstanding in the same Places, or have the same Situation and Position, in regard to one another.

Species, in Algebra, are those Letters, Notes, Marks, or Symbols, which represent the Quantities in any Equation or Demonstration. This short and advantageous way of Notation was introduced by *Vieta*, about the Year 1590, and by it made many Discoveries in the Process of Algebra, not before taken notice of.

The Reason why *Vieta* gave this Name of Species to the Letters of the Alphabet subservient to Algebra, and why he calls it *Arithmetica Speciosa*, seems to have been in imitation of the Civilians, who call Cases in Law, but abstractedly, between *John a Nokes* and *Tom a Stiles*, between A and C; supposing those Letters to stand for any Persons indefinitely; such Cases, I say they call Species: Wherefore since the Letters of the Alphabet will also as well represent Quantities, as Persons; and that too indefinitely one Quantity as well as another, they may properly enough be called Species; that is Symbols, Marks, or Characters. From whence the literal Algebra is frequently now-a-days called Specious Arithmetic, or Algebra in Species.

Specific, is in general whatever is peculiar to any distinct Species of Things, and which distinguishes them from all others of different Species; therefore the Logicians say, that in every good Definition of any thing, the specific Difference ought always to be inserted.

Specific Gravity, is the appropriate and peculiar Gravity or Weight which any Species of natural Bodies have, and by which they are plainly distinguishable from all other Bodies of different kinds. By some 'tis not improperly called *Relative Gravity*, to distinguish it from *Absolute Gravity*, which increases in proportion to the Bigness of the Body weighed.

Sphere, is a solid Body made by the entire Rotation of a Semi-Circle about its Diameter.

1. All Spheres are to one another, as the Cubes of their Diameters.

2. The Solidity of a Sphere is equal to the Surface multiplied into one third of the Radius.

3. The Surface of the Sphere is equal to four times the Area of a great Circle of it.

4.

4. As 2904 to 49, ſo is the Cube of the Circumference of a Sphere to its ſolid Content.

5. As 22 is to 7, ſo is the Square of the Circumference of the greateſt Circle of a Sphere to the ſuperficial Area of the Sphere.

6. As 21 is to the Sine, ſo is 11 times the Square of that Sine added to 33 times the Square of half the Chord of any Segment of a Sphere to the ſolid Content of that Segment.

7. As 14 is to 44 times the Diameter of any Sphere, ſo is the Length of the Sine of any Segment of it, to the Convex Superficies of the ſaid Segment.

8. An entire Glaſs Sphere will unite the parallel Rays of an Object at the Diſtance of near its Semi-Diameter behind it.

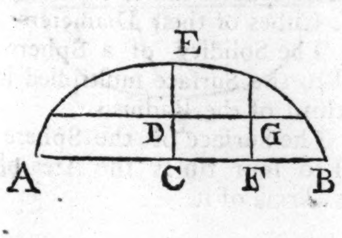
Sphere *of Activity* of any Body, is that determinate Space or Extent all round about it, to which, and no farther, the Effluviums continually emitted from that Body do reach, and where they operate according to their Nature.

Spherical Numbers. See *Circular Numbers*.

Spheric Geometry, or Projection, is the Art of deſcribing on a Plane the Circles of the Sphere, or any Parts of them in their juſt Poſition and Proportion, and of meaſuring their Arches and Angles when projected.

Spheroid, is a ſolid Figure made by the entire Rotation of a Semi-Ellipſis about its Axis.

1. If AEB be a Spheroid generated by the Revolution of the Ellipſis AEB about the Axis AB,



and if it be cut by four Planes, AB paſſing through the Axis; DG parallel to AB, CDE, perpendicularly biſſecting the Axis; and FG parallel to CE; and if the Right Line $CB = a$, $CE = c$, $CF = x$, and $FG = y$: Then the Segment CDGF of the Spheroid comprehended under the ſaid Planes will be $= 2cxy -$

$$\frac{x}{3c}y^3 - \frac{x}{20c^3}y^5 - \frac{x}{56c^5}y^7 - \frac{5x}{576c^7}y^9 - \&c.$$

$$- \frac{cx^3}{3aa} - \frac{x^3}{18caa} - \frac{x^3}{40c^3aa} - \frac{5x^3}{336^5aa} - \&c.$$

$$- \frac{cx^5}{20a^4} - \frac{x^5}{40ca^4} - \frac{3x^5}{160c^3a^4} \&c.$$

$$- \frac{cx^7}{56a^6} - \frac{5x^7}{336ca^6} \&c.$$

$$- \frac{5cx^9}{576a^8} \&c.$$

2. Where the numeral Co-Efficients of the Terms ($2, -\frac{1}{3}, -\frac{1}{20}, -\frac{1}{56}$, &c.) are produced by multiplying the firſt Co-Efficient 2 by the Terms of this Progreſſion —

$$\frac{1\times2}{2\times3}, \frac{2\times3}{4\times5}, \frac{3\times5}{6\times7}, \frac{5\times7}{8\times9}, \frac{7\times9}{10\times11}, \&c.$$

and the numeral Co-Efficients in each Column of the deſcending Terms are produced, by multiplying continually the Co-Efficients of the upper Term in the firſt Column, by the ſame Progreſſion; but in the ſecond by the Terms of this,

$$\frac{1\times1}{2\times3}, \frac{3\times3}{4\times5}, \frac{5\times5}{6\times7}, \frac{7\times7}{8\times9}, \&c.$$

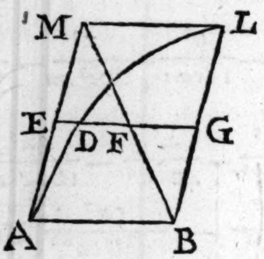
In the third, by the Terms of this,

$$\frac{9\times7}{8\times9}, \frac{3\times1}{2\times3}, \frac{5\times3}{4\times5}, \frac{7\times5}{6\times7}, \frac{9\times7}{8\times9}, \&c.$$

In the fourth, by the Terms of this $\frac{5\times1}{2\times3}, \frac{7\times3}{4\times5}, \frac{9\times5}{6\times7}, \&c.$

3 3.

3. A Spheroid generated by an Ellipsis revolving upon the Diameter thereof, is $\frac{2}{3}$ of its circumscribing Cylinder. Suppose ADLB be a Quadrant of an Ellipsis, then if the whole Figure (AL) is conceived to revolve upon the Semi-Diameter BL, the Semi-Ellipsis ALB will describe a Semi-Spheroid, and the Parallelogram AMLB a Cylinder; and lastly, the Triangle MBL a Cone, all having the same Base and Altitude.



Now, draw any Line EG parallel to the Base, then by the Nature of the Ellipsis $\overline{BL}^2 : \overline{AB}^2 : \overline{BL}^2 - \overline{BG}^2 : \overline{GD}^2$. But from the similar Triangles BML, BFG, we have $\overline{BL}^2 : \overline{AB}^2 (= \overline{ML}^2 = \overline{EG}^2) :: \overline{GB}^2 : \overline{GF}^2$. And (*alternando*) $\overline{BL}^2 : \overline{GB}^2 :: \overline{AB}^2 : \overline{GF}^2$. And (*dividendo*) $\overline{BL}^2 : \overline{AB}^2 :: \overline{BL}^2 - \overline{GB}^2 : \overline{AB}^2 - \overline{GF}^2$. Whence, since before it was $\overline{BL}^2 : \overline{AB}^2 :: \overline{BL}^2 - \overline{BG}^2 : \overline{GD}^2$; therefore (11. 5. *Eucl.*) $\overline{AB}^2 - \overline{GF}^2$, that is $\overline{EG}^2 - \overline{GF}^2 = \overline{DG}^2$; and so $\overline{EG}^2 = \overline{DG}^2 + \overline{FG}^2$. Whence,

4. The Circle made by the Revolution of (FG) will be equal to the *Annulus* described by (ED,) and the Sum of all the Circles (FG,) that is, the Solidity of the Cone will be equal to the Sum of all the *Annuli*, that is, the Excess by which the Cylinder exceeds the Spheroid. Therefore, the Proposition is manifest, that a Spheroid, generated by an Ellipsis, revolving upon any Diameter thereof, is two thirds of its circumscribing Cylinder. Q. E. D.

The great Geometrician, Mr. *Huygens*, in his *Horolog. Oscill.* gives the following two most elegant Constructions for describing a Circle equal to the Superficies of an oblong and prolate Spheroid, which, he says, he found out towards the latter End of the Year 1657.

Let an oblong Spheroid be generated by the Rotation of an Ellipsis ADBE, (*Fig.* 1.) about its transverse Axis AB, and let DE be its Conjugate; make DF equal to CB, or let F be one of the Foci, and draw BG parallel to FD, and a-

Fig. 1.

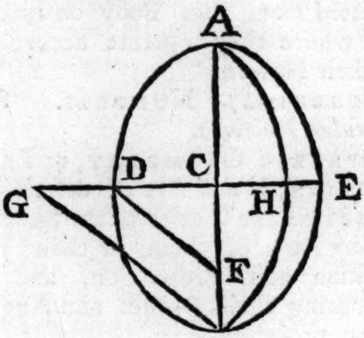
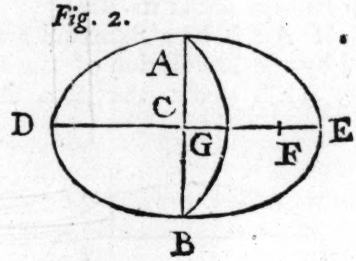


Fig. 2.



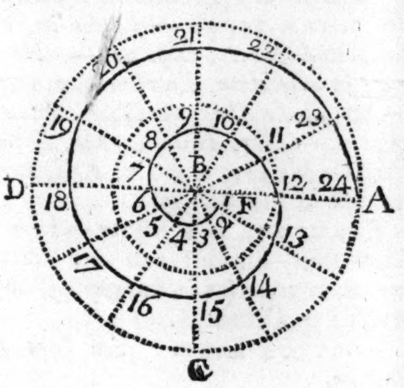
bout

bout the Point G with the Radius BG describe an Arch BHA of a Circle; then between the Semi-Conjugate CD, and a Right Line equal to DE+ the Arch AHB, find a mean Proportional, and that will be the Radius of a Circle equal to the Superficies of the oblong Spheroid.

Let a prolate Spheroid be generated by the Rotation of the Ellipsis ADBE (*Fig.* 2.) about its conjugate Axis AB. Let F be one of the Foci, and bissect CF in G, and let AGB be the Curve of the common Parabola whose Base is the conjugate Diameter AB, and Axis CG. Then if between the transverse Axis DE, and a Right Line equal to the Curve AGB of the Parabola, a mean Proportional be taken, the same will be the Radius of a Circle equal to the Surface of that prolate Spheroid.

Spiral Line, in Geometry, is according to *Archimedes* thus generated.

1. If a Right Line, as AB, having one end fixed at B, be equally moved round, so as with the other end A, to describe the Periphery of a Circle; and at the same time a Point be conceived to move forward equally from B towards A in the Right Line BA, so as that the Point describes that Line, while the Line generates the Circle: then will the Point, with its two Motions, describe



the Curve-Line B, 1, 2, 3, 4, 5, &c. which is called an *Helix*, or *Spiral Line*; and the plain Space contained between the Spiral-Line and the Right-Line BA, is called the *Spiral Space*.

2. If also you conceive the Point B to move twice as slow as the Line AB, so as that it shall get but half-way along BA, when that Line shall have formed the Circle, and if then you imagine a new Revolution to be made of the Line carrying the Point, so that they shall end their Motion at last together; there will be formed a double Spiral Line, and two Spiral Spaces, as you see in the Figure.

3. The Lines B12, B11, B10, &c. making equal Angles with the first and second Spiral, (as also B12, B10, B8, &c.) are in Arithmetical Proportion.

4. The Lines B7, B10, &c. drawn any how to the first Spiral, are to one another as the Arches of the Circle intercepted betwixt BA, and those Lines.

5. Any Lines drawn from B to the second Spiral, as B18, B22, &c. are to each other, as the aforesaid Arches, together with the whole Periphery added on both sides.

6. The first spiral Space, is to the first Circle, as 1 to 3.

7. The first Spiral Line is equal to half the Periphery of the first Circle; for the Radii of the Sectors, and consequently the Arches, are in a simple Arithmetic Progression, while the Periphery of the Circle contains as many Arches equal to the greatest; wherefore the Periphery to all those Arches is to the Spiral Line, as 2 to 1.

Spirals (Proportional,) are such Spiral Lines as the Rhumb Lines on the Terrestrial Globe.

Spring-Arbor, in a Watch, is that part in the middle of the Spring-

Box, which the Spring is wound or turn'd about, and to which it is hooked at one end.

SPRING-BOX, is that Cylindrical Case or Frame that contains within it the Spring of a Watch, or other Movement.

SPRING-TIDE, is the increasing higher of a Tide after a dead Neipe: This is about three Days before the Full or Change of the Moon; but the top, or highest of the Spring Tide is three Days after the Full or Change; then the Water runs highest with the Flood, and lowest with the Ebb, and the Tides run more strong and swift than in the Neipes.

SPRINGY; the same as *Elastic*. Which see.

SPUNGING *of a great Gun*, is clearing of her Inside, after she hath been discharged, with a Wad of Sheep-Skin. or the like, rolled about one end of the Rammer: Its Design is to prevent any Parts of Fire from remaining in her; which would endanger the Life of him who should load, or charge her again.

SQUARE, is an Instrument of Brass or Wood, having one side perpendicular, or at Right Angles to the other; sometimes made with a Joint to fold for the Pocket, and sometimes has a Back to use on a Drawing-Board, to guide the Square.

SQUARE FIGURE, in Geometry, is one whose Right-lined Sides are all equal, and its Angles all right. See *Quadrilateral Figure. For its Area*, see *Area*.

SQUARING. By the word Squaring, Mathematicians understand the making of a Square equal to a Circle. Thus the Quadrature or Squaring of the Circle, is the finding a Square equal to the Area of a Circle.

STAR in Fortification, is a Work with several Faces generally composed of from five to eight Points, with saliant and re-entring Angles flanking one another, every one of its Sides containing from 12 to 25 Fathoms.

STAR-FORT. See *Fort*.

STARS. See *Fixed Stars*.

STATICAL BAROSCOPE. See *Baroscope*.

STATICAL HYGROSCOPE. See *Hygroscope*.

STATICS, is a Science purely speculative, being a Species of Mechanics conversant about Weights, and shewing the Properties of the Heaviness and Lightness, or Æquilibria of Bodies: When it is restrained to the specific Weights and Æquilibria of Liquors, it is called Hydrostatics. Which see.

STATION, in Astronomy, signifies certain Places of the Zodiac, where a Planet being arrived, seems to stand still for some time in the same Degree, either in ascending to its Apogee, or descending to its Perigee.

Apollonius Pergæus has shewn how to find the Stationary Point of a Planet, according to the Old Theory of the Planets, which supposes them to move in Epicycles; which was followed by *Ptolemy* in his *Almag.* lib. 12. cap. 1. and others till the time of *Copernicus*. See concerning this, *Regiomontanus in Epitome Almagesti*, lib. 12. prop. 1. — *Copernicus*'s *Revolutiones Cœlest.* lib. 5. cap. 35, 36.— *Kepler in Tabulis Rudolphinis*, cap. 24.— *Harman in Miscellan. Berolinens.* p. 197. —*Ricciolus's Almagest*. lib. 7. Sect.5. cap. 2.— Dr. *Halley*, Mr. *Facio*, Mr. *De Moivre*, and Dr. *Keil*, have treated of this Subject.

STATION, is a Place where a Man fixes himself and his Instrument, to take (as in Surveying) any Angles or Distances.

STATION-LINE. See *Line of Station*.

Station-Staff, is an Instrument consisting of two Rulers that slide to ten Foot, divided into Feet and Inches, with a moving Vane or Sight, two of which are used with a Level; and on the Edges, there are the Links of *Gunter*'s Chain divided. It is used in Surveying, for the more easy taking Off-sets.

Stationary: A Planet is said to be Stationary, when, to any Eye placed on Earth, it appears for some time to stand still, and to have no progressive Motion forward in its Orbit round the Sun.

Stentoreophonick Tube, or Instrument, is the Speaking Trumpet, invented by Sir *Samuel Moreland*.

Mr. *Durham*, in his *Physico-Theology*, Lib. 4. Chap. 3. says, that *Kircher* found out this Instrument 20 Years before Sir *Samuel Moreland*, and published it in his *Musurgia*; and *Casper Schottus* is said to have seen one at the *Jesuits* College at *Rome*.—One *Conyers*, in the *Philos. Transact.* N° 141. gives a Description of an Instrument of this kind, different from those commonly made; and Mr. *s'Gravesande*, in his *Philosophy*, finds fault with the Figures of these Instruments as generally made, where he would have them to be parabolick Conoids, with the Focus of one of its parabolick Sections, to fit the Mouth.—See concerning this Instrument too in *Sturmy*'s *Collegium Curiosum*, Part 2. Tentam. 8.

Stereobata, in Architecture, is the *Greek* Word for the first Beginning of the Wall of any Building, and immediately standing on the Foundation. This is wrongly confounded with *Stylobata*, which is the Beginning of a Column, or its Pedestal.

Stereography, is the Art of drawing the Forms of Solids upon a Plane.

Stereographick *Projection of the Sphere*, is the Projection of the Circles of the Sphere upon the Plane of some one great Circle, the Eye being in the Pole of that Circle.

In this Projection, a Right Circle is projected into a Line of Half Tangents.

The Representation of a Right Circle perpendicularly opposed to the Eye, will be a Circle in the Plane of the Projection.

The Representation of a Circle placed oblique to the Eye, will be a Circle in the Plane of the Projection.

If a great Circle be to be projected upon the Plane of another great Circle, its Centre shall lie in the Line of Measures, distant from the Centre of the Primitive by the Tangent of its Elevation above the Plane of the Primitive.

If a lesser Circle, whose Poles lie in the Plane of the Projection, were to be projected; the Centre of its Representation shall be in the Line of Measures, distant from the Centre of the Primitive, by the Secant of that lesser Circle's Distance from its Pole, and its Semidiameter or Radius shall be equal to the Tangent of that Distance.

If a lesser Circle were to be projected, whose Poles lie not in the Plane of the Projection, its Diameter in the Projection, if it falls on each side of the Pole of the Primitive, will be equal to the Sum of the Half Tangents of its greatest and nearest Distance from the Pole of the Primitive, set each Way from the Centre of the Primitive in the Line of Measures.

If a lesser Circle, to be projected, falls entirely on one side of the Pole of the Projection, and does not encompass it, then will its Diameter be equal to the Difference of the Half-Tangents of its greatest and

nearest Distance from the Pole of the Primitive, set off from the Centre of the Primitive one and the same Way in the Line of Measures.

In the Stereographick Projection, the Angles made by the Circles on the Surface of the Sphere, are equal to the Angles made by their Representatives in the Plane of their Projection.

STILE. See *Style*.

STRAIT, or *Streight*, in Hydrography, is a narrow Sea shut up between Lands on either side, affording a Passage from one great Sea into another, as the Strait of *Magellan*, the Strait of *Gibraltar*, &c.

STRIKING-WHEEL, in a Clock, is that which by some is called the Pin-Wheel; because of the Pins which are placed upon the Round or Rim, (which in Number are the Quotient of the Pinion, divided by the Pinion of the Detent-Wheel.) In 16 Days Clocks, the first or great Wheel is usually the Pin-Wheel; but in Pieces that go eight Days, the second Wheel is the Pin-Wheel, or striking Wheel.

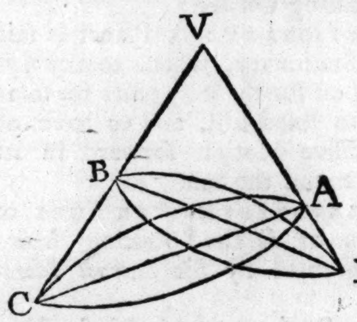
STYLE, in Dialling, is that Line whose Shadow on the Plane of the Dial shews the true Hour-Line. This is always supposed to be a Part of the Axis of the Earth, and therefore must always be so placed, as that with its two extreme Points it shall respect the two Poles of the World, and with its upper End, the elevated Pole. This Line is the upper Edge of the Cock, Gnomon, or Index.

STYLOBATA, in Architecture, is the Pedestal of a Column or Pillar.

STYLOBATON, or *Stylobata*, in Architecture, is the same with the Pedestal of a Column. This is sometimes taken for the Trunk of the Pedestal, between the Cornice and the Base; and then called Truncus, as it is also by the Name of Abacus.

SUBCONTRARY POSITION, in Geometry, is when two similar Triangles are so placed as to have one common Angle V at the Vertex, and yet their Bases are not parallel.

And therefore if the Scalenous Cone B V D be so cut by the Plane C A, as that the Angle C = D, the



Cone is then said to be cut subcontrarily to its Base BD; and the Section C A of a Cone thus cut is a Circle.

SUBDUCTION, the same with *Substraction*; which see.

SUBDUPLE RATIO, is when any Number or Quantity is contained in another twice: Thus 3 is said to be Subduple of 6, as 6 is double of 3.

SUBDUPLICATE RATIO of any two Quantities, is the Ratio of their square Roots.

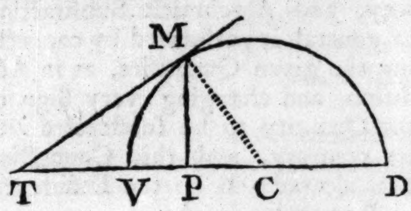
SUBLUNARY, are all Things that are in the Earth, or in the Atmosphere thereof, below the Moon.

SUBMULTIPLE NUMBER, or *Quantity*, is that which is contained in another Number, a certain Number of Times exactly: Thus, 3 is Submultiple of 21, as being contained in it 7 Times exactly.

SUBMULTIPLE PROPORTION, the Reverse of Multiple. Which see.

SUBNORMAL, is a Line, as PC, determining in any Curve the Intersection of the Perpendicular to the Tangent in the Point of Contact, with the Axis. And this Subnormal in the common or *Apollonian* Paraboal,

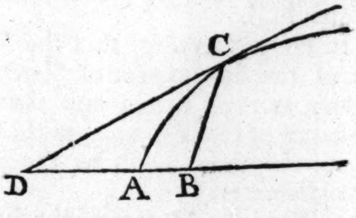
Parabola, is a determinate invariable Quantity; for 'tis always equal to half the Parameter of the Axis.



Substitution, in Algebra, or Fluxions, is the putting in the room of any Quantity in an Equation ſome other Quantity which is really equal to it, but expreſſed after another manner.

Subtangent, in a Curve, is a Line, as T P, which determines the Interſection of the Tangent in the Axis or a Diameter; and in any Equation, if the Value of the Subtangent comes out poſitive, 'tis a ſign that the Point of Interſection of the Tangent and Axis falls on that Side of the Ordinate, where the Vertex of the Curve lies; as in the Parabola and Paraboloids: But if it comes out negative, the Point of Interſection will fall on the contrary Side of the Ordinate, in reſpect of the Vertex or Beginning of the Abſciſſa; as in the Hyperbola and Hyperboliform Figures. And univerſally in all Paraboliform and Hyperboliform Figures, the Subtangent is equal to the Exponent of the Power of the Ordinate multiplied into the Abſciſſa.

If C B be an Ordinate to A B in any given Angle terminating in any



Curve A C, and $AB = x$, $BC = y$, and the Relation between x and y, that is, the Nature of the Curve, be expreſſed by this Equation, $x^3 - 2xxy + bxx - bbx + byy - y^3 = 0$, then this will be the Rule of drawing a Tangent to it: Multiply the Terms of the Equation by any Arithmetical Progreſſion; according to the Dimenſions of y, ſuppoſe

$$\begin{array}{cccccc} x^3 & -2xxy & +bxx & -bbx & +byy & -y^3; \text{ as} \\ 0 & 1 & 0 & 0 & 2 & 3 \end{array}$$

alſo according to the Dimenſions of x, as,

$$\begin{array}{cccccc} x^3 & -2xxy & +bxx & -bbx & +byy & -y^3; \\ 3 & 2 & 2 & 1 & 0 & 0 \end{array}$$

the former Product ſhall be the Numerator, and the latter, divided by x, the Denominator of a Fraction expreſſing the Length of the Subtangent BD, which in this Caſe will be

$$= \frac{-2xxy + 2byy - 3y^3}{3xx - 4xy + 2bx - bb}.$$

Substylar Line, in Dialling, is that Line drawn on the Plane of the Dial, over which the Style ſtands at Right-Angles with the Plane. This is always the Repreſentation of the Meridian of that Place, where the Plane of the Dial is Horizontal. The Angle between this Line and the true Meridian, is the Plane's Difference of Longitude, and is meaſured on the Equinoctial.

Subsuper-Particular Proportion, is contrary to *Super-Particular Proportion*. Which ſee.

Subtense, or *Chord of an Arch*, is a Right Line extended from one End of that Arch to the other End thereof.

Substraction, in general, is taking a leſſer Quantity from a greater, to find the Difference between them, which is commonly called the Remainder, as the leſſer Quantity to be ſubſtracted is called the Subſtrahend.

Substraction of whole Numbers is performed by placing the leſſer under the greater, as in Addition, and then beginning at the

Right Hand, taking each Figure below from that above, and ſetting down the ſeveral Remainders, or Differences underneath, and the Number ſubſcribed will be the Difference, or Remainder, of the two Numbers. But when any one of the Figures of the under Number is greater than that of the upper, from which it is to be taken, you muſt add 10 (in your Mind) to that upper Figure; and having taken the anſwerable under one from this Sum, ſet the Difference underneath, and add an Unit to the Figure next to be ſubſtracted. Example 1. From 9758 let us ſubtract 3514. Place them thus,

$$\begin{array}{r} 9758 \\ \underline{3514} \\ 6244 \end{array}$$ the Difference, or Remainder.

Example 2. From 945 ſubtract 608.

$$\begin{array}{r} 945 \\ \underline{608} \\ 737 \end{array}$$ the Remainder.

SUBSTRACTION in Decimal Fractions is the ſame as in whole Numbers, always obſerving to put every Figure of the ſame Place under the like Place above, and imagining all void Places to be ſupplied with Cyphers. Examples.

From	352.09	.576	79.
Take	63.74	.0829	.2987
Remains	288.35	.4931	78.7013

SUBSTRACTION of Vulgar Fractions is performed by taking the Numerator of the leſſer Fraction from that of the greater, and ſetting down the Difference for the Numerator of the Fraction wanted, its Denominator being the ſame as either of the Denominators of the given Fractions; which Denominators muſt either be equal at firſt, or elſe made ſo by reducing the Fractions to a common Denominator. As if from $\frac{5}{7}$ you are to take $\frac{3}{7}$, then will the Remainder be $\frac{2}{7}$ And if from $\frac{6}{11}$ you take $\frac{3}{14}$, you muſt firſt reduce theſe Fractions to two others $\frac{84}{154}$ and $\frac{33}{154}$ equal to them, and then their Difference will be $\frac{51}{154}$. Algebraick Fractions are ſubſtracted much after the ſame way, and Algebraick Subſtraction in general is performed by connecting the given Quantities, as in Addition, and changing every Sign of the Quantity to be ſubſtracted into its contrary, and this Connection thus altered will be the Difference, or Remainder ſought.

The general Sign or Mark of Subſtraction is —

SUBTRIPLE RATIO, is when any one Number or Quantity is contained in another three times. Thus 2 is ſaid to be ſubtriple of 6, as 6 is the Triple of two.

SUBTRIPLICATE RATIO, is the Ratio of the Cube-Roots.

SUCCESSION *of Signs*, is that Order in which they are uſually reckon'd: As, firſt, *Aries*, next, *Taurus*, then *Gemini*, &c. This is otherwiſe called Conſequence.

SUCULA, or *Succula*, is a Term in Mechanicks for a Bare Axis or Cylinder, with Staves in it to move it round, but without any Tympanum or Peritrochium.

SUN. Our excellent Sir *Iſaac Newton* ſaith, in his *Principia*, that the Denſity of the Sun's Heat (which is proportional to his Light) is ſeven times as great at *Mercury* as with us; and therefore our Water there would be all carried off, and boil away: For he found by Experiments of the Thermometer, that an Heat but ſeven times as great as that of the Sun-Beams in Summer, will ſerve to make Water boil.

1. He proves alſo, that the Matter of the Sun to that of *Jupiter* is nearly as 1100 to 1; and that the Diſtance of that Planet from the Sun, is in the ſame Ratio as the Sun's Semidiameter.

2. That the Matter of the Sun to that of *Saturn*, is as 2360 to 1; and the

the Diſtance of *Saturn* from the Sun is in a Ratio but little leſs than that of the Sun's Semidiameter: And conſequently, that the common Centre of Gravity of the Sun and *Jupiter* is nearly in the Superficies of the Sun; of *Saturn* and the Sun, a little within it.

3. And by the ſame manner of Calculation it will be found, that the common Centre of Gravity of all the Planets, cannot be more than the Length of the Solar Diameter diſtant from the Centre of the Sun: This common Centre of Gravity he proves to be at reſt; and therefore tho' the Sun, by reaſon of the various Poſition of the Planets, may be moved every way, yet it cannot recede far from the common Centre of Gravity, and this, he thinks, ought to be accounted the Centre of our World. *Book* 3. *Prop.* 12.

4. By means of the Solar Spots it hath been diſcovered, that the Sun revolves round its own Axis, without moving (conſiderably) out of his Place, in about twenty five Days, and that the Axis of this Motion is inclined to the Ecliptick in an Angle of 87 Degrees 30 Minutes nearly. The Sun's apparent Diameter being ſenſibly ſhorter in *December* than in *June*, as is plain, and agreed from Obſervation, the Sun muſt be proportionably nearer to the Earth in Winter than in Summer; in the former of which Seaſons will be the Perihelion, in the latter the Aphelion: And this is alſo confirmed by the Earth's moving ſwifter in *December*, than it doth in *June*; as it doth about $\frac{1}{15}$.

5. For ſince, as Sir *Iſaac Newton* hath demonſtrated, by a Line drawn to the Sun, the Earth always deſcribes equal Areas in equal Times, whenever it moves ſwifter, it muſt needs be nearer to the Sun: And for this Reaſon there are about eight Days more from the Sun's Vernal Equinox to the Autumnal, than from the Autumnal to the Vernal.

6. The Sun's Diameter is equal to an hundred Diameters of the Earth; and therefore the Body of the Sun muſt be 1000000 times greater than that of the Earth.

Mr. *Azout* aſſures us, that he obſerved by a very exact Method the Sun's Diameter to be no leſs than 21 Minutes 45 Seconds in his Apogee, and not greater than 32 Minutes 45 Seconds in his Perigee.

7. The mean apparent Diameter of the Sun, according to Sir *Iſaac Newton*, is 32 Minutes 12 Seconds, in his Theory of the Moon.

8. If you divide 360 Degrees (*i. e.* the whole Ecliptick) by the Quantity of the Solar Year, it will quote 59 Minutes 8 Seconds, *&c.* which therefore is the Quantity of the Sun's Diurnal Motion; and if this 59 Minutes 8 Seconds be divided by 24, you have the Sun's Horary Motion, which is 2 Minutes 28 Seconds; and if you will divide this laſt by 60, you will have his Motion in a Minute, *&c.* And this Way are the Tables of the Sun's mean Motion, which you have in the Books of Aſtronomical Calculation, conſtructed.

9. The Sun's Horizontal Parallax, Dr. *Gregory* and Sir *Iſaac Newton* make but 10 Seconds.

Sunday Letter, the ſame with *Dominical Letter*.

Superficial Numbers, the ſame with *Plain Numbers*.

Superficies, the ſame with Surface, (which ſee,) is Length and Breadth only, without Thickneſs.

The Notion of a Line's being made up of an infinite Number of equidiſtant Points; of a Superficies, of an infinite Number of equidiſtant Lines; and of a Solid's, of an infinite Number of equidiſtant Surfaces or Superficies, is falſe, and will lead a Perſon into a Multitude of

Absurdities in the Investigation of Proportions of the Surfaces of Bodies, &c. For if a Pyramid or Cone be conceived, the one as made up of an infinite Number of equidistant Squares, and the other as made up of an infinite Number of equidistant Circles parallel to their respective Bases, continually increasing as the Squares of the Natural Numbers, it will from thence follow, that the Surfaces of any two Pyramids, or Cones, of the same Base and Altitude, will be equal, which every one knows is false: And the Reason why from this Notion a true Conclusion is sometimes drawn, when the Proportions of Plain Surfaces, or of Solids, contain'd between the same Parallels, is sought, is because the infinite Number of Parallelograms, of which a Plain Figure may consist, and the infinitely small Parallelepipedons, of which a Solid does, when their Proportions are sought, are all of the same infinitely small Height, and so they are to each other as their Bases; whence these Bases, in this Case, may be taken for the Correspondent Parallelograms or Parallelepipedons, and so no Error will arise.

SUPER-PARTICULAR PROPORTION, is when one Number or Quantity contains another once, and one such Part whose Numerator is 1; then the Number so contained in the greater, is said to be to it in super-particular Proportion.

SUPER-PARTIENT PROPORTION, is when one Number or Quantity contains another once, and some Number of aliquot Parts remaining; as, $1\frac{2}{3}$, $1\frac{2}{4}$, $1\frac{2}{5}$, &c.

SUPPLEMENT *of an Arch*, in Geometry, or Trigonometry, is the Number of Degrees that it wants of being an entire Semi-Circle; as the Complement signifies what an Arch wants of being a Quadrant.

SURD ROOTS, or *Numbers*.

1. When any Number or Quantity hath its Root proposed to be extracted, and yet is not a true figurate Number of that kind, that is, if its Square Root being demanded, it is not a true Square, &c. then 'tis impossible to assign, either in whole Numbers or Fractions, any exact Root of such a Number proposed; and whenever this happens, 'tis usual in Mathematicks, to mark the required Root of such Numbers or Quantities, by prefixing before it the proper Marks of Radicality, $\surd$. Thus, $\sqrt{2}$ signifies the Square Root of 2. and $\sqrt[3]{16}$. or $\surd(3)\ 16$. signifies the Cubical Root of 16. Which Roots, because they are impossible to be expressed in Numbers exactly, (for no Number, either Integer or Fraction, multiplied into itself, can ever produce 2, or being multiplied Cubically, can ever produce 16,) are very properly called *Surd Roots*.

2. There is also another Way of Notation, now much in use, whereby Roots are expressed, without the Radical Sign, by their Indexes: Thus, as x^2. x^3. x^5. &c. signify the Square, Cube, and fifth Power of x; so $x^{\frac{1}{2}}$. $x^{\frac{1}{3}}$. $x^{\frac{1}{4}}$. &c. signify the Square Root, Cube Root, &c. of x. The Reason of which is plain enough; for since $\sqrt{x}$ is a Geometrical mean Proportional between 1 and x, so $\frac{1}{2}$ is an Arithmetical mean Number between 0 and 1; and therefore as 2 is the Index of the Square of x, $\frac{1}{2}$ will be the proper Index of its square Root, &c.

3. Observe also, that for Convenience or Brevity sake, Quantities or Numbers, which are not Surds, are often expressed in the Form of Surd Roots: Thus $\sqrt{4}$, $\sqrt{\frac{9}{4}}$, $\sqrt[3]{27}$, &c. signify, 2, $\frac{3}{2}$, 3, &c.

SURDS are either simple, which are expressed by one single Term, or

elſe compound, which are formed by the Addition or Subſtraction of ſimple Surds: As, $\sqrt{5} + \sqrt{5} - \sqrt{2}$. or $\sqrt[3]{7 + \sqrt{2}}$. Which laſt is called an Univerſal Root; and ſignifies the Cubick Root of that Number, which is the Reſult of adding 7 to the Square Root of 2.

SURFACE, (the ſame with Superficies) is the bare Outſide of any Body; and conſidered by it ſelf, is Quantity extended in Length and Breadth only, without Thickneſs.

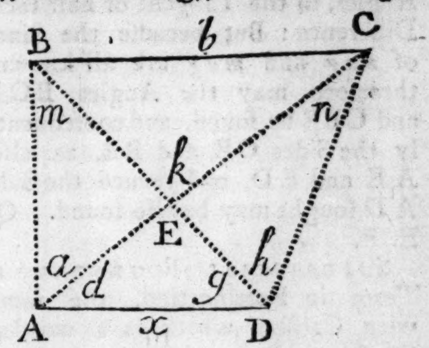
SURSOLID LOCUS. See *Locus Surſolid.*

SURSOLID PROBLEM, in Mathematicks, is that which cannot be reſolved but by Curves of a higher Nature than a Conick Section, *v. gr.* in order to deſcribe a Regular Endecagon, or Figure of eleven Sides in a Circle, 'tis required to deſcribe an Iſoſceles Triangle on a Right Line given, whoſe Angles at the Baſe ſhall be quintuple to that at the Vertex; which may eaſily be done by the Interſection of a Quadratrix, or any other Curve of the ſecond Gender.

SURVEYING *of Land*, or *Planometria*, is the Art of meaſuring all manner of Plain Figures, in order to know their ſuperficial Cotent; which how to do, I have ſhewn all along, under the particular Name of each Plane Figure: But how to bring this to Practice, ſo as to meaſure the Areas of Real Lands, Fields, Grounds, &c. by the Help of proper Inſtruments, is what we uſually call Surveying.

The following uſeful Problem being uncommon, and the Solution eaſily following from the Inveſtigation, I thought it might not be amiſs to inſert it.

The Side BC given, together with the Angles BAC, CAD, ADB, BDC, to find the Side AD, let us call the Side BC (b), the Angle BAC (a), and the Angle CAD (d), alſo BDA (g), and the Angle



BDC (h), and the Angle AED, (which is alſo given) (k), and the Angles B, C, (m and n), and laſtly the Side AD, (x); then it will be as the Sine of the Angle (k) is to (x) :: Sine (g) : $\frac{gx}{k}$ = A E. And as the Sine of the Angle (k) is to (x), ſo is the Sine of (d) to $\frac{xd}{k}$ = E D. Alſo as the Sine (m) : $\frac{xg}{k}$ (A E) :: ſo is the Sine of (a) : to $\frac{xga}{mk}$ = B E. And as the Sine of (n) : $\frac{xd}{k}$ = (E D) :: ſo is the Sine of (h) to $\frac{xdh}{nk}$ = (C E.) Now as B E + E C : E C — B E :: ſo is the Tangent of half the Sum of the Angles B C E and C B E (which are given) to the Tangent of half their Difference: Therefore as

$$\frac{x \times \overline{nag + mdh}}{mnk} \text{ (B E + E C)} :$$

$$\frac{x \times \overline{mdh - nag}}{mnk} \text{ (E C — B E)} ::$$

ſo is the Tangent of half the Sum of the Angles B C E, C B E, to the Tangent of half their Difference. But becauſe $\frac{x}{mnk}$ is in both Terms

of

of the Ratio, it will be as the Sines of $nag + mdb : mdb - nag ::$ so is the Tangent of half the Sum of the Angles, to the Tangent of half their Difference: But because the Sines of nag and mdg are all known, therefore may the Angles BCE and CBE be found, and consequently the Sides CE and BE, as also AE and ED, and thence the Side AD sought may be also found. Q. E. P.

Superficial Fourneau, a Term in Fortification, the same with Caisson, which is a wooden Chest, or Box, with three, four, five, or six Bombs in it; and sometimes 'tis filled only with Powder, and is used in a close Siege, by being buried under Ground with a Train to it, to blow up any Lodgment that the Enemy shall approach to.

Surveying Scale, the same with *Reducing Scale*.

Swallows-Tail, in Fortification, is a single Tenaille, that is narrower towards the Place than towards the Country.

Swing-Wheel, in a Royal Pendulum, is that Wheel which drives the Pendulum. This Wheel in a Watch is called the Crown Wheel, as also in a Balance Clock.

Sydereal Year. See *Year*.

Symmetry, in Architecture, comes from the *Greek Symmetria, with Measure*, and signifies the Relation of Parity, both as to Height, Depth, and Breadth, which the Parts have, in order to form a beautiful Whole. In Architecture we have both uniform Symmetry, and respective Symmetry: In the former, the Ordonance is pursued in the same manner throughout the whole Extent; whereas in the latter, only the opposite Sides correspond to each other.

Syncopation, a Term in Musick, which is when a Note of one Part ends and breaks off upon the Middle of a Note of another Part.

Syncope, in Musick, is the Driving Note, when some shorter Note perfixed at the Beginning of the Measure, or Half-Measure, is followed by two, three, or more Notes of a greater Quantity, before you meet with another short Note equivalent to that which began the Driving, to make the Number even; as when an odd Crotchet comes before two, three, or more Minims, or an odd Quaver before two, three or more Crotchets.

Synodical Month, is the Space of Time (*viz.* 29 Days, 12 Hours, 45 Minutes) contained between the Moon's parting from the Sun at a Conjunction, and returning to him again; during which Time she puts on all her Phases. And her

Synodical Revolution, is that Motion whereby her whole System is carried along with the Earth round the Sun.

Synthetical Method *of Enquiry*, or *Demonstration*, in Mathematicks, is when we pursue the Truth, chiefly by Reasons drawn from Principles before established, and Propositions formerly proved, and proceed by a long regular Chain, till we come to the Conclusion; as is done in the Elements of *Euclid*, and in almost all the Demonstrations of the Ancients. This is called *Composition*, and is opposed to the Analytical Method, which is called Resolution. Which see.

Syphon, is a Tube or Pipe of Glass or Metal, which is usually bent to an Acute Angle, and having one Leg shorter than the other. They are frequently used to draw off Liquors out of one Barrel or Vessel into another, without raising the Lees, or Dregs, and are called Cranes. Sometimes Glass Tubes or Pipes, tho' strait, are called *Syphons*.

System, in Musick, is the Extent of a certain Number of Chords, having its Bounds toward the Grave and Acute, which hath been differently determined by the different Progress made in Musick, and according to the different Divisions of the Monochord.

The System of the Ancients was composed of four Tetrachords, and one supernumerary Chord, the whole making fifteen Chords.

System, properly is a regular orderly Collection, or orderly Disposition of all those Planets, which move round the Sun as their Centre, in determined Orbits, and never deviate farther from him than their proper and usual Bounds. And a

System *of Philosophy*, is a regular Collection of the Principles and Parts of that Science into one Body, and a treating of them dogmatically, or in a scholastical Method; which is called the *Systematical Way*, in contradistinction of the Way of Essay, wherein the Writer delivers himself more loosely, easily and modestly.

Systile, in Architecture, is that Manner of placing Columns where the Space between the two Fusts consists of two Diameters, or four Modules.

Syzygy, in Astronomy, is the same with the Conjunction of any two Planets or Stars, or when they are both referred to the same Point in the Heavens; or to the same Degree of the Ecliptick, by a Circle of Longitude passing through them both.

T.

Tailier: See *Abacus*.

Talon, a little Member in Architecture, consisting of a square Fillet, and a streight Cymatium, and is only two Portions of a Circle.

Talus, in Architecture, is the same with *Astragalus*; which see: But in Fortification it signifies any Thing that goes sloping; or it is the *French* Word for a Slope.

Tangent of a Curve is a Right Line, which so meets a part of a Curve, as not to cut that part.

Taper-Bored, a Term in Gunnery. A Piece of Ordnance is said to be Taper-Bored when it is wider at the Mouth than towards the Breech.

Telescope, is a Dioptrick Instrument, composed of Lens's, by means of which remote Objects appear as if they were near.

It is certain that *Johannes Baptista Porta*, a *Neapolitan*, was the first that made a Telescope, about the Year 1594: For he says, in *Magis. Natur. lib.* 17. *c.* 10. *Si utrumque* (that is, a Concave and Convex Glass) *rectè conjungere noveris, & longinqua & proxima majora, & clara videbis, non parum multis amicis auxilii præstitimus, qui & longinqua obsoleta, proxima turbida conspiciebant, ut omnia perfectissime contuerentur.* But *Porta* did not well understand his own Invention, which he had found out by Chance, and so had not effected it with any great Industry, or applied the same to Celestial Observations. Not long after him, there were several others that made short Telescopes; but they were of small Use, till *Galileo* applied himself to the making of one, who was the first that made it tolerably good.

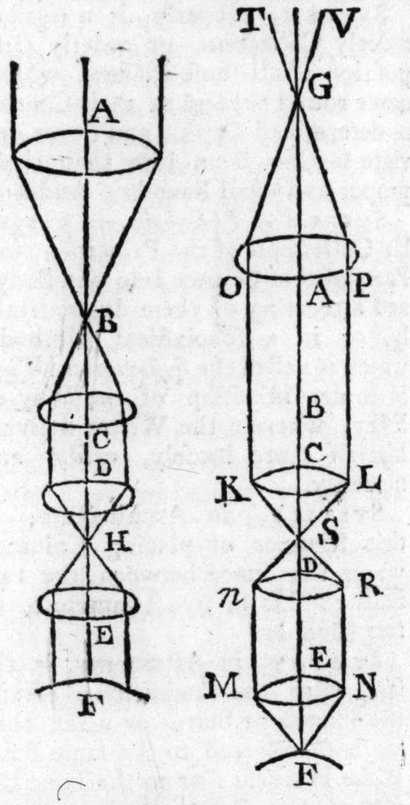
A Telescope, made by a convex and concave Lens, represents vastly distant Objects, distinct and erect; and magnifies them according to the Proportion of the Focal Distance of the Convex Lens, to the Focal Distance of the Concave Lens.

A Telescope, made of two Convex Lens's, represents vastly distant Objects, distinct but inverted; and magnifies them according to the Proportion of the Focal Distance of the Exterior or Object Lens, to the Focal Distance of the Interior or Ocular Lens.

Here follows the Explanation of the Construction of a Telescope compounded of four Convexes, by means of which Objects are seen erect, and very ample.

Telescopes, made of two Convexes, because of their Inverting the Position of the Object, are seldom used, except in observing the Stars, the Position of which is not regarded. The Proportion in which this Sort magnifies the Object, has already been shewn; but if we would have these Images again made erect, and at the same time a great Share of them be represented to the Eye, at one View, very ample, we must use three, four, five, or more Lens's; which, however, are not to be multiplied without Cause, because the Matter of each of them, and the Reflexion of their several Surfaces, divert Part of the Rays: But we cannot obtain the desired Effect perfectly, with fewer than four Lens's. For although, in the same Length of the Telescope, both an erect Situation, and the same Degree of magnifying, and an equal Share of the Object, may be had as well with three as four Lens's, yet the Composition of three Lens's is much more inconvenient than that of four; because in that, the two Ocular Lens's, or, at least, that which is next the Eye, must be made of larger Segments of a Sphere, with respect to its Diameter, or to the Focal Distance, if the same Magnitude of the Visual Angle be required: And hence the Objects come to be Coloured; and Right Lines, at the Margins of the Aperture appear Curve: Therefore we must make our Telescope of four Lens's, which is done after the following Manner:

The Exterior, or Object Lens, is A, whose Focal Distance is A B, and in the same Axis are placed three Ocular Lens's C, D, and E, all equal to one another, the inmost of which is placed beyond the Focus B, by its Focal Distance B C;



and the next D, is placed beyond C, by twice that Distance B C, and the last as far from D as that was from C; and lastly, the Eye must be placed beyond this last by the Distance B C.

There is here again Occasion for two Figures; in the first of which are represented Rays proceeding from a single Point of the vastly distant Object; which, 'tis plain to any who understand what has gone before,

fore, First, fall, as it were, parallel upon the Lens A, and are by it collected at its Focus B; and thence diverging, fall upon the Lens C, which makes them again parallel, and throws them upon the Lens D, which collects them at its Focus H, the middle Point of the Distance DE; from whence proceeding on to the Lens E, they are by it made a third time parallel; and being received so by the Eye F, they make distinct Vision by being collected at its Focus which is in the bottom of the Eye.

The other Figure considers the Proportion of magnifying, which is that which AB, the Focal Distance of the Object Lens, bears to BC, the Focal Distance of one of the Ocular Lens's, and demonstrates likewise the Amplitude of the visual Angle. For the Apertures of the three Ocular Lens's, being supposed equal, which must not exceed the Apertures of the Object Lens A, draw M*n*, NR, parallel to the common Axis; and comprehending the Diameters of the Apertures of the Lens's E and D, and also KO, LP, parallel to the same Axis, and comprehending KL the Aperture of the Lens C; and taking AG, equal to AB, draw the Lines OGV, PGT, intersecting one another in G. Now, it is evident, the Latitude of the Object which is seen by the naked Eye from the Point G, and consequently from F also, the Distance of the Object being as it were infinite, would appear comprehended in the Angle MFN; and consequently the Proportion of the apparent Magnitude to the true, is as the Angle MFN to the Angle TGV or PGO; that is, PO and MN being equal, as the Distance AG, to the Distance EF; that is, as AB, the Focal Distance of one of the ocular Lens's. Q.E.D.

It appears, moreover, that the visual Angle MFN comprehends the same Latitude of the Object, with a Telescope made of two Lens's, only A and C: for that Share of the Object which is comprehended in the Angle TGV, would be seen through that Telescope in the Angles KSL, equal to the Angles MFN.

This incomparable Composition of Lens's was found out by I know not whom at *Rome*; and may be much improved by placing an Annulus or Ring either at H, the common Focus of the Lens's D and E, or at B, the common Focus of the Lens's A and C; which is especially of very great use in measuring the Diameters of Planets: For this Annulus does therefore exactly circumscribe the Circle of the apparent Images, because it cuts off those irregular Rays which are not collected near enough to B or H, and consequently are not, by means of the succeeding Lens's, sent parallel to the Eye, which distinct Vision requires; and the Colours likewise near the Margins are by this contrivance taken away, which without it are not well to be avoided. The Proportions between the Focal Distance of the Object Lens, (which is likewise the Length of the Telescope,) the Aperture of the same Object Lens, the Focal Distance of the Ocular Lens, and the apparent magnified Diameter of the Object; for Telescopes, from the Length of one *Rhinland* Foot to a hundred, are expressed in the Table following.

A Table for TELESCOPES.

The Focal Distance of the Object Lens, or the Length of the Telescope.	*The Diameter of the Aperture of the Object Lens.*	*The Focal Distance of the Ocular Lens.*	*The Proportion of magnifying considered as to the Diameter.*
Rhinland Feet.	*Inches and Decimals.*	*Inches and Decimals.*	
1.	0,55.	0,61.	20.
2.	0,75.	0,85.	28.
3.	0,95.	1,05.	34.
4.	1,09.	1,20.	40.
5.	1,23.	1,35.	44.
6.	1,34.	1,47.	49.
7.	1,45.	1,60.	53.
8.	1,55.	1,71.	56.
9.	1,64.	1,80.	60.
10.	1,73.	1,90.	63.
13.	1,97.	2,17.	72.
15.	2,12.	2,33.	77.
20.	2,45.	2,70.	89.
25.	2,74.	3,01.	100.
30.	3,00.	3,30.	109.
35.	3,24.	3,56.	118.
45.	3,46.	3,81.	126.
40.	3,67.	0,04.	133.
50.	3,87.	4,26.	141.
55.	4,06.	4,47.	148.
60.	4,24.	4,66.	154.
65.	4,42.	4,86.	161.
70.	4,58.	5,04.	166.
75.	4,74.	5,21.	172.
80.	4,90.	5,39.	178.
85.	5,05.	5,56.	183.
90.	5,20.	5,72.	189.
95.	5,34.	5.87.	194.
100.	5,48.	6,03.	199.

Sir *Isaac Newton*, in his Optics, says, if the Theory of making Telescopes could, at length, be fully brought into Practice, yet there would be certain Bounds beyond which Telescopes could not perform: For the Air through which we look upon the Stars, is in perpetual Tremor, as may be seen by the tremulous Motion of Shadows cast from high Towers, and by the twinkling of the fixed Stars. But these Stars do

do not twinkle when viewed through Telescopes, which have large Apertures; for the Rays of Light, which pass through divers Parts of the Aperture, tremble each of them apart; and, by means of their various, and sometimes contrary Tremors, fall at one and the same time upon different Points in the bottom of the Eye, and their trembling Motions are too quick and confused to be perceived severally: And all these illuminated Points constitute one broad lucid Point, composed of those many trembling Points, confusedly and insensibly mixed with one another by very short and swift Tremors, and thereby cause the Star to appear broader than it is, and without any trembling of the whole. Long Telescopes may cause Objects to appear brighter and larger than short ones can do; but they cannot be so formed as to take away that Confusion of the Rays which arises from the Tremors of the Atmosphere. The only Remedy is a most serene and quiet Air, such as may perhaps be found on the tops of the highest Mountains above the the grosser Clouds.

Telescope (Aerial) is one of Mr. *Huygens*'s, described in the *Philosophical Transactions*, pag. 161. made for using only in the Night; and so having no close Tube, since there is no need of one in the Night.

Telescope (Reflecting,) consists of a large Tube, open at one end, being that next to the Object, and having the other end close, where a Concave Metalline Speculum is placed; and having near the open End a flat Oval Speculum inclined towards the upper part of the Tube, where is a little hole furnished with a small plane Convex Eye-Glass. There is a full account of this Instrument by Sir *Isaac Newton*, in the *Philosophical Transactions*, numb. 81. and in numb. 376. Mr. *Hadley* has given us a Description of an Instrument of this kind of five Feet one fourth in Length; which, used as a Night-Telescope, will magnify about two hundred and twenty times, and, as a Day-one, about one hundred twenty-five times; and is in several respects superior, and in none inferior to Mr. *Huygens*'s Dioptric Telescope of one hundred and twenty-six Feet in Length.

Mr. *Jackson*, an ingenious Mathematical Instrument-Maker, has lately made one of those reflecting Telescopes, the largest that I ever saw, being six Feet long and seven Inches in Diameter, and magnifying the Objects 200 times.

Telescopical Stars, are those that are not visible to the naked Eye, but discoverable only by the help of a Telescope.

Temperate Zone. See *Zone*.

Temporary Fortification. See *Fortification*.

Tenaille, in Fortification, is a kind of Out-Work resembling a Horn-Work, but generally somewhat different; in regard that instead of two Demi-Bastions, it bears only in Front a re-entring Angle between the same Wings without Flanks, and the Sides are parallel: But when there is more Breadth at the Head than at the Gorge, these Tenailles are called *Queuë d'hironde*. All Tenailles are defective in this respect, that they are not flanked or defended towards their inward or dead Angle, because the Height of the Parapet hinders seeing down before the Angle; so that the Enemy can lodge himself there under Covert: Wherefore Tenailles are never made, but when they want time to make Horn-Works.

Tenor, is the Name of the first Mean or middle Part in Musick.

Term, in Geometry is taken for

for the Bounds and Limits of any thing.

TERMS *of an Equation*, in Algebra, are the several Names or Members of which it is composed, and such as have the same unknown Letter, but in different Powers or Degrees: For if the same unknown Letter be found in several Members in the same Degree or Power, they shall pass but for one Term.

As, in this Equation, $xx + ax = bb$; the three Terms are xx, ax, and bb. Moreover, in this, $x^4 + x^3 + x^2 + \frac{ab}{cd} x + \frac{fp}{rs} x + yy = 0$; the Terms are x^4, x^3, x^2, $\frac{ab}{cd} + \frac{fp}{rs} \times x$, and yy. Where $\frac{ab}{rs} x$, and $\frac{fp}{rs} x$, are the same Terms; and the first Term in any Equation must be that where the unknown Root hath the highest Dimensions; and that Term which hath the Root in it, of one Dimension of Power lower, is called the second Term, and so on.

TERMS *of Proportion*, in Mathematicks, are such Numbers, Letters, or Quantities, as are compared one with another.

Thus if $\begin{matrix} 2.\ 4 :: c.\ d. \\ a.\ b :: 8.\ 16 \end{matrix}$, then a, b, c, d, or 2, 4, 8, 16, are called the Terms; a being the first Term, b the second Term, &c.

TERRAQUEOUS, in Geography, signifies the Globe of Earth and Water, as they both together constitute one spherical Body.

TERRE (PLAIN) in Fortification, is the Platform or horizontal Surface of the Rampart lying level, only with a little slope on the outside for the Recoil of the Cannon.

It is terminated by the Parapet on that side toward the Field, and by the inner Talus on the other toward the Body of the Place.

TERRELLA: When a Loadstone is made spherical, and is placed so that its Poles and Equator, &c. do exactly correspond to the Poles and Equator of the World, it is called by *Gilbert* a *Terella*, or little Earth; being in some measure a Representation of our great Globe of Earth.

TERRESTRIAL GLOBE. See *Globe*.

TERRESTRIAL LINE. See *Line Terrestrial*.

TETRACHORD, in Music, is a Concord or Interval of three Tones.

The Tetrachord of the Ancients, was a Rank of four Strings, accounting the Tetrachord for one Tone, as it is often taken in Music.

TETRA DIAPASON. A Quadruple Diapason is a musical Chord, otherwise called a quadruple eighth, or nine and twentieth.

TETRACONIAS, a Comet, whose Head is of a quadrangular Figure, and its Tail or Train long, thick, and uniform; and does not differ much from the Meteor called *Trabs*.

TETRAHEDRON, is one of the regular Bodies, consisting of four equal equilateral Triangles; or it is a triangular Pyramid of four equal Faces.

TETRASTYLE, in Architecture, is a Building which hath four Columns in the Faces before and behind.

TEXTURE. The Texture of any natural Body, is that particular Disposition of its constituent Particles, as makes it have such Form, or be of such a Nature, or be endow'd with such Qualities.

THEODOLITE, is an Instrument used in Surveying, and taking of Heights and Distances; and consisteth of several Parts, as a Circle of Brass, about one Foot Diameter,

divided into four Quadrants, ſometimes with a Teleſcope at the bottom of it.

Each of the Quadrants is divided into ninety Degrees, and ſubdivided as the Largeneſs of the Inſtrument will permit.

A Box and Needle contrived to ſtand upon the Centre of the Circle, upon which Centre, the Inſtrument, the Index, with its Sights, and ſometimes a Teleſcope, is made to turn about; and yet, both the Inſtrument, and the Box and Needle, remain firm. At the bottom of the Box, there is a Card, or Mariner's Compaſs fix'd.

A Socket on the Backſide, to be put upon the Head of a three-legged Staff.

A Staff to ſet the Inſtrument upon; the Neck, at the Head whereof, muſt be made to go into the Socket on the Backſide of the Inſtrument.

N. B. I muſt do Mr. *Thomas Heath* (Mathematical Inſtrument-Maker, near the *Fountain-Tavern* in the *Strand*,) the Juſtice to ſay, that I have ſeen excellent Theodolites made by him, as well as all other Mathematical Inſtruments.

THEOREM, is a ſpeculative Propoſition, demonſtrating the Properties of any Subject.

THERMOSCOPE is an Inſtrument ſhewing the Increaſe and Decreaſe of Heat and Cold in the Air: But the

THERMOMETER is an Inſtrument by which we can meaſure the Heat and Cold of the Air.

It is uſually made of a Tube of Glaſs of about four Foot long, filled with tinged Spirit of Wine, or ſome other proper Liquor, having a Ball at the bottom of it.

THREE-LEGGED-STAFF, is an Inſtrument conſiſting of three wooden Legs, made with Joints to ſhut all together, and to take off in the middle, for the better Carriage; and on its top is uſually a Ball and Socket to ſupport and adjuſt Inſtruments for Aſtronomy, Surveying, &c.

TIDE. Tide ſignifies as well the Ebbing as the Flowing of the Sea; the former of which the Seamen call Tide of Ebb; the latter, Tide of Flood.

In a Lunar Day, that is, the Time ſpent between the Moon's going from the Meridian, and coming to it again, the Sea is twice elevated, and twice depreſſed, in any aſſigned Place.

In any Place the Water is moſt elevated, two or three Hours after the Moon has paſs'd the Meridian of the Place, or the oppoſite Meridian.

The Elevation towards the Moon a little exceeds the oppoſite one. The Aſcent of the Water is diminiſhed as you go towards the Poles, becauſe there is no Agitation of the Water there.

From the Action of the Sun, every natural Day the Sea is twice elevated, and twice depreſſed. This Agitation is much leſs, on account of the immenſe Diſtance of the Sun, than that which depends upon the Moon; yet it is ſubject to the ſame Laws.

The Motions which depend upon the Action of the Moon and Sun, are not diſtinguiſhed but confounded; and from the Action of the Sun, the Lunar Tide is only changed; which Change varies every Day, by reaſon of the Inequality between the Natural and Lunar Day.

In the Syzygies the Elevations from the Action of both Luminaries concur, and the Sea is more elevated; the Sea aſcends leſs in the Quadratures; for where the Water is elevated by the Action of the Moon, it is depreſſed by the Action

of the Sun, and so on the contrary. Therefore, whilst the Moon passes from the Syzygy to the Quadrature, the daily Elevations are continually diminished: On the contrary, they are increased when the Moon moves from the Quadrature to the Syzygy. At a new Moon also, *Cæteris paribus*, the Elevations are greater, and those that follow one another the same Day, are more different than at Full Moon.

The greatest and least Elevations are not observ'd, till the second or third Day after the New or Full Moon. If we consider the Luminaries receding from the Plane of the Equator, we shall perceive that the Agitation is diminished, and becomes less, according as the Declination of the Luminaries becomes greater.

In the Syzygies, near the Æquinoxes, the Tides are observed to be the greatest, both Luminaries being in or near the Equator.

The Actions of the Moon and Sun are greater, the less those Bodies are distant from the Earth; but when the Distance of the Sun is less, and it is in the South Signs, often both the greatest Æquinoctial Tides are observed in that Situation of the Sun, that is, before the Vernal, and after the Autumnal Æquinox; which yet does not happen every Year, because some Variation may arise from the Situation of the Moon's Orbit, and the Distance of the Syzygy from the Æquinox. In Places distant from the Equator, the Elevations that happen the same Day are unequal.

As long as the Moon is on the same Side of the Equator in any Place, the Elevation of the Water is observed to be the greatest every Day, after the Moon has passed the Meridian of the Place.

But if the Equator separates, or is between the Moon and the Place of which we speak, the Water will come to the greatest Height; and every Day the greatest Elevation of the Sea will be after the Moon has passed thro' the opposite Meridian.

All Things which have been hitherto explained would exactly obtain, if the whole Surface of the Earth was covered with Sea; but since the Sea is not every where, some Changes arise from thence; not indeed in the open Sea, because the Ocean is extended enough to be subject to the Motions we have spoken of. But the Situation of the Shores, the Streights, and many other Things depending upon the particular Situation of the Places, disturb these general Rules: Yet it is plain from the most general Observations, that the Tide follows the Laws which we have laid down.

The mean Force of the Sun to move the Sea, is to the mean Force of the Moon to move the same, as 1 to 4.4815.

The Action of the Sun changes the Height of the Sea two Feet; and that the Action of the Moon changes it 8,95: And that, from the joined Action of both, the mean Agitation is of about eleven Feet, which agrees pretty well with Observations. For, in the open Ocean, as the Sea is more or less open, the Water is raised to the Height of six, nine, twelve, or fifteen Feet; in which Elevations, also there is a Difference arising from the Depth of the Waters; but those Elevations, which far exceed these, happen where the Sea violently enters into the Streights or Gulphs, where the Force is not broken till the Water arises higher.

TIME, in Music, is that Quantity or Length whereby is assigned to every particular Note its due Measure, without making it either longer or shorter than it ought to be; and it is twofold, *viz.* Duple or Common, and Triple.

Time (Duple,) or *Semi-breve*, generally called *Common*, because most used, is when all the Notes are increased by two.

Time (Triple,) is that wherein the Measure is counted by Threes.

Time, is a Succession of Phænomena, and the Idea that we have thereof, consists in the Order of successive Perceptions: It is divided into Absolute and Relative.

Time (*Astronomical, Mathematical*, or *Absolute*,) flows equably in it self, without relation to any Thing external; and, by another Word, is called *Duration*. But,

Time (*Relative, Apparent*, or *Vulgar*,) is the sensible and external Measure of any Duration estimated by Motion; and this the Vulgar use instead of true Time.

Tondino, a Term in Architecture. See *Astragal*.

Tone, a Term in Music, signifying a certain Degree of Elevation or Depression of the Voice, or some other Sound.

Topography, is a particular Description of some small Quantity of Land, such as that of a Manor, or particular Estate, &c.

Torrid Zone. See *Zone*.

Torus, in Architecture, is a large round Moulding in the Bases of the Columns.

Trabeation, the same with *Entablement*.

Trajectory *of a Comet*, is the Line which, by its Motion, it describes.

Transcendental Curves, are such as when their Nature or Property is express'd by an Equation, one of the variable Quantities therein denotes a Curve Line; and when such Curve Line is a Geometrick one, or one of the first Degree or Kind, then the Transcendental Curve is said to be of the second Degree or Kind, &c.

Transit, in Astronomy, signifies the passing of any Planet just by or under any fix'd Star; or of the Moon, in particular, covering or moving close by any other Planet.

Transition, in Music, is when a greater Note is broken into a lesser, to make smooth or sweeten the Roughness of a Leap by a gradual Transition, or passing to the Note next following; whence it is commonly called the Breaking of a Note, being sometimes very necessary in Musical Composition.

Transmutation, in Geometry, is to reduce or change one Figure or Body into another of the same Area or Solidity, but of a different Figure; as a Triangle into a Square, a Pyramid into a Parallelopiped, &c.

Transparent, or *Diaphanous Bodies*, are such as may be seen through.

Transposition, in Algebra, is to bring any Term of an Equation over to the other Side, as if $a+b=c$; and you make $a=c-b$, then is b transposed.

Transverse Axis, or *Diameter of an Ellipsis*, is the longer Axis.

Trapezium, in Geometry, is a Plane Figure contained under four unequal Right Lines.

1. Any three Sides of a Trapezium taken together, are greater than the third.

2. The two Diagonals of any Trapezium do divide it into four proportional Triangles.

3. If two Sides of a Trapezium be parallel, the Rectangle under the Aggregate of the parallel Sides, and one half their Distance, is equal to that Trapezium.

4. If a Parallelogram circumscribes a Trapezium, so that one of the Sides of the Parallelogram be parallel to a Diagonal of the Trapezium, that Parallelogram will be the double of the Trapezium.

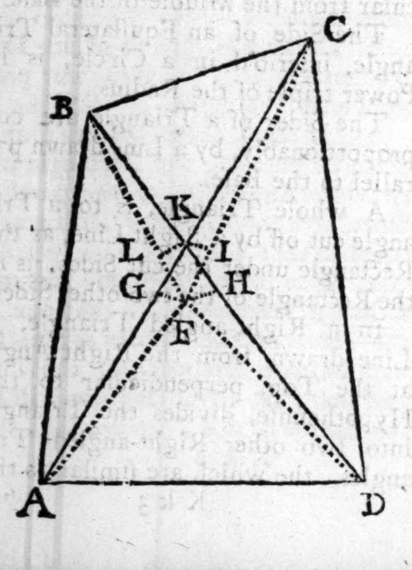
5. If any Trapezium has two of its opposite Angles, each a right Angle, and a Diagonal be drawn joining these Angles; and if from the other two Angles be drawn two Perpendiculars to that Diagonal, the Distances from the Feet of these Perpendiculars to those right Angles, respectively taken, will be equal.

6. If the Sides of a Trapezium be each bissected, and the Points of Bissection be joined by four right Lines; these right Lines will form a Parallelogram, which will be one half of the Trapezium.

7. If the Diagonals of a Trapezium be each bissected, and a right Line joins those Points; the Aggregate of the Squares of the Sides is equal to the Aggregate of the Squares of the Diagonals, together with four times the Square of the Line joining the Point of Bissection.

8. In any Trapezium ABCD, the Aggregate of the Diagonals AC, BD, is less than the Aggregate of four right Lines drawn from any Point (except the Intersection of the Diagonals) within the Figure.

Let K be the Intersection of the Diagonals, and conceive the Point F to be infinitely near to K, from which draw four right Lines AF, FB, FC, FD, to the Angles, and



from F, K, let fall the Perpendiculars FG, FH to AK, DK, and KI, KL to FC, FB; then will GK be the infinitely small Decrement of AK; KH that of DK; IF the infinitely small Increment of KC, and LF that of BK. But since the Angle FBH is infinitely small, KH will differ from LF only by an infinitely small Quantity, which may therefore be rejected; so that $KH = LF$. In like manner $GK = FI$. Therefore $GK + KH + FI + LF = 0$. But it is well known, that when the Aggregate of any Number of variable Lines KB, KC, KA, KD, becomes a Minimum, or Maximum, the Aggregate of their Increments and Decrements will be equal to nothing. Wherefore it is evident that the Diagonals AC, BD, are either less or greater than those of any four right Lines drawn from any Point, except K, within the Figure to the four Angles. But they cannot be greater, consequently they must be less.

The Truth of this Proposition appears almost evident by Inspection; for suppose the Point F to be at any finite Distance from K, the Intersection of the Diagonals AC, BD, and draw, as before, the Lines AF, BF, CF, DF; then the Side AC of the Triangle ACF, is shorter than the two Sides $AF + FC$; and the Side BD of the Triangle FBD shorter than the Sides $BF + FD$. Therefore $AC + BD$ is less than $AF + FC + BF + FD$.

Trapezoid, is a solid irregular Figure, having four Sides not parallel to one another.

Traverse, a Term in Gunnery, signifying to turn a Piece of Ordnance which way one pleases upon her Platform.

Also the laying and removing a Piece of Ordnance, or a great Gun, in order to bring it to bear or lie level with the Mark, is called Traversing the Piece.

Traverse, in Navigation, is the Variation or Alteration of the Ship's Course upon the shifting of Winds, &c.

Traverse, in Fortification, is a little Trench, bordered with two Parapets, *viz.* one on the right Side, and the other on the left, which the Besiegers make quite thwart the Moat of the Place, to pass secure from Flank-Shot, and to bring the Miners to the Bastions.

Treble, is the last or highest of the four Parts in Musical Proportion.

Trenches, in Fortification, are certain Moats or Ditches, which the Besiegers cut to approach more securely to the Place attacked, and are of several sorts, according to the different Nature of the Soil; for if the adjacent Territory be rocky, the Trench is only an Elevation of Bavins, Gabions, Wool-Packs, or Shouldrings of Earth, cast up round about the Place: But where the Ground may be easily opened, the Trench is dug therein, and bordered with a Parapet on the Side of the Besieged. The Breadth of it ought to be from 8 to 10 Foot, and the Depth from 6 to 7.

These Trenches are to be carried on with winding Lines, in some manner parallel to the Works of the Fortress, so as not to be in View of the Enemy, nor to expose its Length to their Shot, which they call Ensilading; for then it will be in danger of being ensiladed or scoured by the Enemies Cannon: and this carrying of the Trenches obliquely, they call, carrying the Trenches by Coudees or Traverses.

Triangle, in Geometry, is a Figure of three Sides and three Angles; and is either a Plane Triangle, or a Spherical one.

A *Plane Triangle*, is contained under three Right Lines.

A *Spherical Triangle*, is contain'd under three Arches of a great Circle of the Sphere.

Of Triangles there are several sorts, as,

1. A *Right-angled Triangle*, is that which hath one Right Angle.

2. An *Obtuse-angled Triangle*, is such as hath one Obtuse Angle.

3. An *Acute-angled Triangle*, is that which hath all its Angles acute.

4. Any *Triangle* that is not Right-angled, is called *Oblique-angled*, or *Amblygonial*.

5. An *Equilateral Triangle*, is that which hath all its Sides equal to one another.

6. An *Isosceles*, or an *Equilegged Triangle*, is that which hath only two Sides equal.

7. A *Scalenous Triangle*, is that which has no two Sides equal.

In every Triangle, the Sum of all the three Angles is equal to two Right ones; and the External Angle made by any Side produced, is equal to the Sum of the Internal and its Opposite one.

In every Triangle, as well Plane as Spherical, the Sines of the Sides are proportional to the Sines of the opposite Angles.

If a Perpendicular be let fall upon the Base of an Oblique-angled Triangle, the Difference of the Squares of the Sides is equal to the Double Rectangle under the Base, and the Distance of the Perpendicular from the Middle of the Base.

The Side of an Equilateral Triangle, inscrib'd in a Circle, is in Power triple of the Radius.

The Sides of a Triangle are cut proportionably, by a Line drawn parallel to the Base.

A whole Triangle, is to a Triangle cut off by a Right Line, as the Rectangle under the cut Sides, is to the Rectangle of the two other Sides.

In a Right-angled Triangle, a Line drawn from the Right Angle at the Top, perpendicular to the Hypothenuse, divides the Triangle into two other Right-angled Triangles, the which are similar to the

first Triangle, and to one another.

In every Right-angled Triangle, the Square of the Hypothenuse is equal to the Sum of the Squares of the other two Sides.

If any Angle of a Triangle be bissected, the bissecting Line will divide the opposite Side in the same Proportion as the Legs of the Angle are to one another.

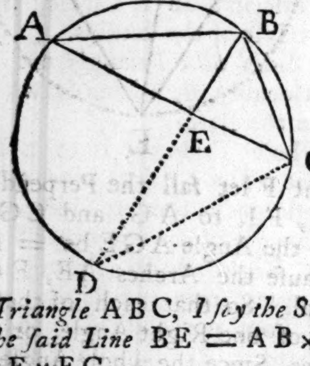
Triangles on the same Base, and having the same Height, that is between the same Parallel Lines, are equal.

Every Triangle is one half of a Parallelogram of the same Base and Height.

The Area of any Triangle may be had by adding all the three Sides together, and taking half the Sum; and, from that half Sum, subtracting each Side severally, and multiplying that half Sum and the Remainder continually one into another, and extracting the Square Root of the Product.

The following useful Proposition, being one of those mentioned by Sir *Isaac Newton* in his *Algebra*, which is necessary to be known by all those who intend to apply Algebra to Geometry; but he neither demonstrating it, nor directing where it is demonstrated, therefore I have given a Demonstration thereof.

If there be any Right Line BE *which bissects the Angle* ABC *of*



the Triangle ABC, *I say the Square of the said Line* BE $=$ AB $\times$ BC $-$ AE $\times$ EC.

Having described a Circle about the said Triangle, and continued out the Line BE till it cuts the Circle in D, and drawn the Line DC, the Triangles ABE and BCD will be similar, which may be thus proved. The Angle ABE $=$ EBC by Construction; and be-because the Angles BAC and BDC stand upon the same Arch BC, they will likewise be equal; and consequently the Angles AEB, BCD, must be equal. Therefore, as AB : BE : : DB : BC, whence AB $\times$ BC $=$ BE $\times$ DB. But since AE $\times$ EC $=$ BE $\times$ ED from the Nature of the Circle. And because BE*q* $=$ DB $\times$ BE ($=$ AB $\times$ BC) $-$ ED $\times$ BF, from the Third of the Second of *Euclid*: therefore AB $\times$ BC $-$ AE $\times$ EC $=$BE*q*. Q. E. D.

In any Triangle any one Side is greater than the Difference between the other two Sides, and two Sides is greater than the Third.

In any Triangle the Difference of the Squares of the Sides is equal to the Difference of the Squares of the Segment of the Base, made by letting fall a Perpendicular from the vertical Angle upon the Base; and the Square of one Side, together with the Square of the alternate Segment, is equal to the Square of the other Side, together with the Square of the other Segment.

In any Triangle, if the Base be bissected, and a Right Line be drawn from the Angle opposite to the Base to the Point of Bissection, the Squares of the two Sides together, are equal to twice the Square of the Bissecting Line together, with twice the Square of half the Base.

In every Triangle the Rectangle under the Sides is equal to the Rectangle under the Perpendicular drawn from the vertical Angle to the Base, and the Diameter of the circumscribing Circle.

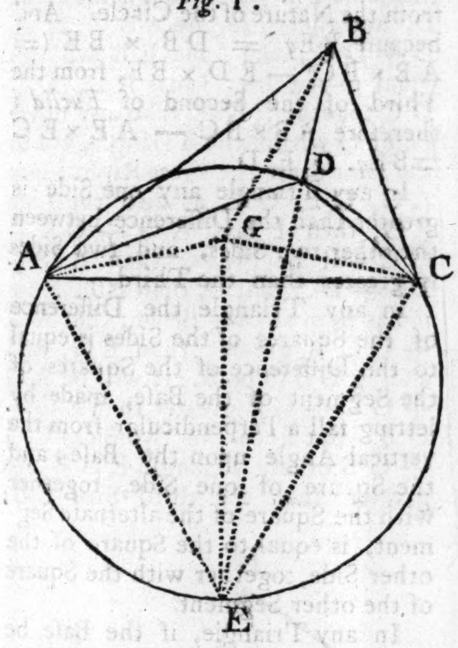
In every Triangle the Angle contained under the Perpendicular to the Base, and the Right Line drawn from

from that Angle to the Middle of the Base, is equal to half the Difference of the Angles at the Base.

In every Triangle the Rectangle under the Aggregate and Difference of the Sides is equal to the Rectangle under the Aggregate and Difference of the Segment of the Base, made by letting fall a Perpendicular from the Vertical Angle to the Base.

If the Point D *be taken within a Triangle* A B C *such, that the Angles* ADB, BDC, ADC, *formed at the same by three Right Lines*

Fig. 1.



AD, BD, DC, *drawn from the Angles* A, B, C, *of the Triangle* ABC, *be equal to each other. I say the Aggregate of those three Right Lines* AD, BD, CD, *will be less than the Aggregate of three other Right Lines drawn from the Angles of the Triangle* ABC, *to any Point besides* D, *taken within that Triangle.*

Before this can be demonstrated, we must lay down the following Lemma.

Lemma 1. *If* EAC *be an equilateral Triangle, and a Triangle* AGC *be constructed upon one Side* AC *thereof, whose two other Sides* AG, GC, *make an Angle equal to one third Part of four right Angles (or* 120 *Deg.) and the Right Line* EG *be drawn, and if any Point* F *be taken in the Line* EG, *and the Right Lines* AF, FC, *be drawn: I say the Aggregate of the Lines* AF, FC, *will be greater than the Line* EF.

Conceive a Circle to be described about the Triangle ACE, which will pass through G, and from the

Fig. 2.

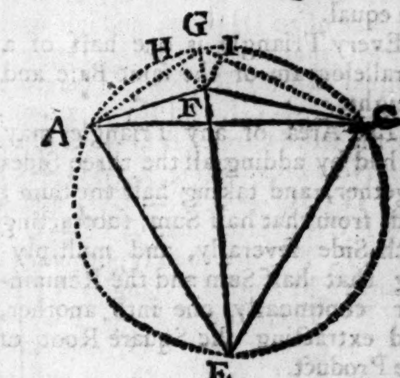
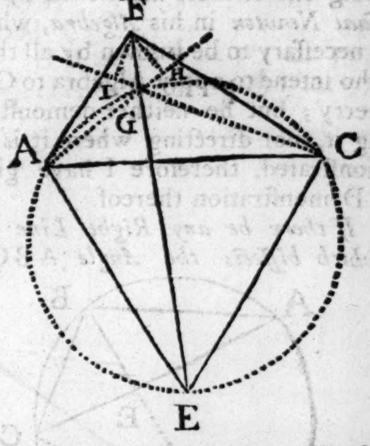


Fig. 3.

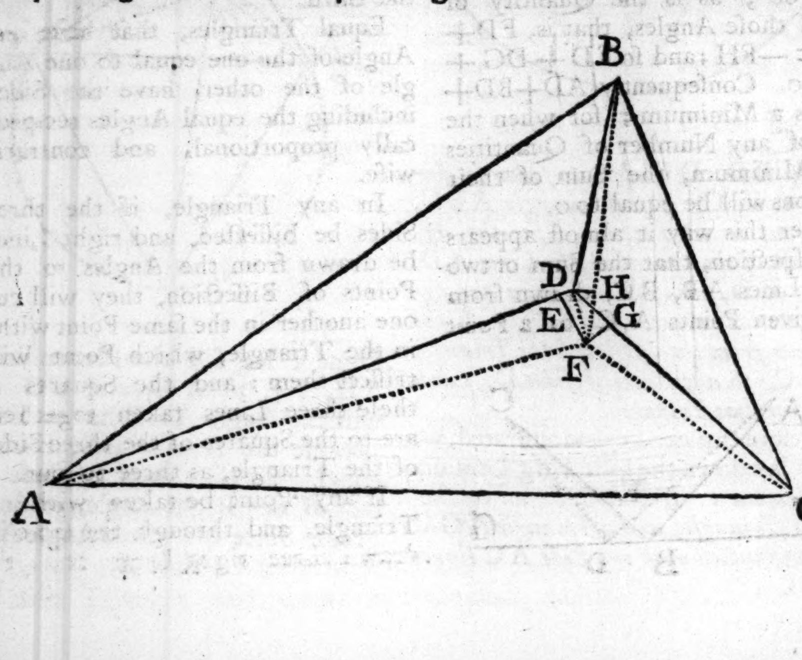


Point F let fall the Perpendiculars FH, FI, to AG, and CG. then will the Angle AGE be = EGC, because the Arches AE, EC, are equal. So that each of these will be $\frac{2}{3}$ of one Right Angle, or 60 Degrees. Since the whole Angle AGC

 is

is ⅔ of two Right Angles, or 120 Degrees, and (in *Fig.* 3) the Angles F G I, F G H will be each ⅔ Parts of one Right Angle, or 60 Degrees, because these are each Vertical to E G A, E G C. Consequently the Angles H F G, I F G of the right-angled Triangles F H G, I H G will be ⅓ Part of a Right Angle or 30 Degrees. So that H G = G I. and G F will be the double of H G. Since, if F G be supposed the Radius, F I and F H will each be the Sine of 60 Degrees, and H G, or G I, the Sine of 30 Degrees; and it is well known that the Sine of 30 Degrees is equal to ½ the Radius. Therefore FG=HG + GI, also (by *n.* 22. under the word Circle) A G + G C = EG. Now because (*Fig.* 2.) AH + CI + F G (HG + G I) = EG, and A F + F C is greater than A H + C I; for A F, F C are the Hypothenuses of the right angled Triangles A F H, C F I. Therefore A F + F C + F G is greater than E G, and taking away F G from both; it will be A F + F C greater than E G — F G, that is, than E F. After the like manner (in *Fig.* 3.) because A H + C I — F G = E G. But A F + F C greater than A H + C I. Therefore A F + F C — F G is greater than E G, and adding F G to both, we shall have A F + F C greater than F G + E G, that is, than E F.

This being granted, upon the Side A C of the Triangle A B C make the equilateral Triangle A E C (*Fig.* 1.) and conceive a Circle to be described about the same; then from what has been already said, the Point D will fall in the Circumference of that Circle, and if the Points E and B be joined by a Right Line; this Line will pass through the Point D, and therefore, since E G = A D + D C; the Line E B will be equal to the three Lines A D, D B, D C together. Now take any other Point G within the Triangle, and to the same draw the three Right Lines A G, G B, G C, as also the Line E G, then I say, A G + G B + G C will be greater than A D + DB + DC, that is, than EB. Now it has been already shewn, that A G + G C is greater than E G, and adding G B to both, it will be A G + G C + G B greater than E G + G B. But since the two Sides E G + G B of any Triangle E G B are greater than the third Side E B;



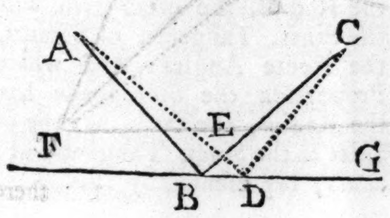
there-

therefore $AG + GC + GB$ will be much greater than EB, that is, than $AD + DB + DC$.

Note, When the Point G is taken in the Periphery of the Circle, the Demonſtration is very ſimple, there being then no Occaſion for the Lemma aforegoing. Wherein

Otherwiſe: Let F be any Point infinitely near to D, from which draw FE, FG perpendicular to AD, DC, and join the Lines AF, FC, FB and FD, and let fall DH perpendicular to BF, then will ED be the Fluxion of AD; DG that of DC; HF that of BD: ſo that if FD be ſuppoſed the Radius, ED will be the Sine of the Angle DFE, DG the Sine of the Angle DFG, and FH the Sine of the Angle FDH. But the Angle EFG is 60 Deg. Since E and G, and EDG being $180° + 120°$, and that the Complement of theſe three to 360°; alſo the Angle FDH ($=FDG + GDH$, that is, $FDG + 30°$,) $= 60° + EFD$. But it is demonſtrated in Trigonometrical Writings, (See *Sherwin*'s *Tables*) That the Sum of the Sines of any two Angles making 60°, is equal to the Sine of an Angle as much above 60°, as is the Quantity of one of thoſe Angles, that is, $ED + DG = -FH$; and ſo $ED + DG + FH = 0$. Conſequently $AD + BD + DC$ is a Minimum; for when the Sum of any Number of Quantities is a Minimum, the Sum of their Fluxions will be equal to 0.

After this way it almoſt appears by Inſpection, that the Sum of two right Lines AB, BC, drawn from two given Points A, C, to a Point



D, in a right Line FG given in Poſition, will be a Minimum, when the Angles ABF, CBG are equal. For if D be taken in FG infinitely near to B, and AD, DC be drawn, and AD cuts BC in E; then ſince the Angles ABF, ADF may be taken for Equals, they differing from one another only by an infinitely ſmall Angle, the Angle CBG will be $= ABF$; and ſo the Sides BE, ED of the ſmall Triangle BED, are equal. But theſe Sides are the Fluxions of the Lines AB, CB; ſo that $ED + EB = 0$, or $ED = -EB$; and therefore $AB + BC$ is a Minimum.

Note, It is very eaſy to demonſtrate this by common Geometry too; by letting fall from A a Perpendicular to FG, and continuing it down below FG till it meets CB continued alſo below FG; for then if any other Point D be taken in FG, and AD be drawn, as alſo CB, which being continued below B, will fall in the ſame Point with the Continuation of AF; it will follow that $AB + BC$ is leſs than $AD + DC$. Since two Sides of any Triangle are greater than the third.

Equal Triangles, that have one Angle of the one equal to one Angle of the other, have the Sides including the equal Angles reciprocally proportional, and contrariwiſe.

In any Triangle, if the three Sides be biſſected, and right Lines be drawn from the Angles to the Points of Biſſection, they will cut one another in the ſame Point within the Triangle, which Point will triſſect them; and the Squares of theſe three Lines taken together, are to the Squares of the three Sides of the Triangle, as three to four.

If any Point be taken within a Triangle, and through the ſame be drawn three right Lines from the Angles

Angles of the Triangle cutting the Sides into ſix Parts, the Parallelepipedon contain'd under the firſt, third, and fifth of theſe Parts orderly taken, is equal to the Parallelepipedon under the ſecond, fourth and ſixth.

If any three ſimilar Figures be deſcribedupon the three ſides of a right-angled Triangle, the Figure upon the Hypothenuſe will be equal to the Figures, taken together, upon the other two ſides.

If one Angle of any Triangle be two third Parts of two right Angles or its Meaſure 120°, the Squares deſcribed upon the Sides containing that Angle, and the Rectangle under thoſe Sides, all three taken together, are equal to the Square deſcribed upon the Baſe. And if the Sides containing that Angle be equal, the Square of the Baſe will be three times the Square of either of the equal Sides. And the Square of the Perpendicular let fall from the vertical Angle upon the Baſe, is one twelfth Part of the Square of the Baſe.

In any Triangle, whoſe vertical Angle is two third Parts of two right Angles, the Difference of the Cubes of the Sides containing that Angle, is equal to a Parallelepipedon, whoſe Baſe is the Square of the Baſe of the Triangle, and Altitude the Difference of the Sides. And the Sum of the Cubes of the Sides, is equal to a Parallelepipedon whoſe Baſe is the difference of the Squares of the Baſe, and twice the Rectangle under the Sides, and Altitude equal to the Aggregate of the Sides of the Triangle.

There are many other Properties of Triangles to be found among the Geometrical Writers; as *Gregory St. Vincent* has wrote a thin Folio Book upon Triangles. You have alſo ſeveral in his *Quadrature* of the Circle.

TRIANGULAR COMPASSES, are ſuch as have three Legs or Feet to take off any Triangle at once.

TRIANGULAR QUARDRANT, is a Sector with a looſe Piece to make it an Equilateral Triangle; the Calendar is graduated on it, with the Sun's Place, Declination, and many other uſeful Lines; and by the Help of a String and a Plummet, and the Diviſions graduated on the looſe Piece, it may be made to ſerve for a Quadrant.

TRIANGULUS SEPTENTRIONALIS, or *Deltoton*. The *Triangle*, a Northern Conſtellation conſiſting of ſix Stars.

TRIGLIPH, in Architecture, is a Member of the *Doric Freeze*, placed directly over each Column, and at equal Diſtances in the Intercolumnation, having two entire Glyphes or Channels engraven in it, meeting in an Angle, and ſeparated by three Legs from the two Demi-Channels of the Sides.

TRIGON, ſignifies a Figure with three Angles: And, in Dialling, is an Inſtrument of a Triangular Form.

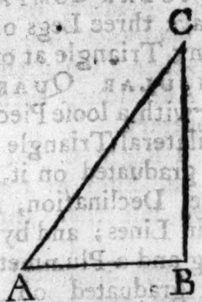
TRIGONOMETRY, is either Plain or Spherical.

TRIGONOMETRY (PLAIN,) is the Art of finding, from three given Parts of a Right-lin'd Triangle, the reſt. And

TRIGONOMETRY (SPHERICAL,) is the Art of finding, from three given Parts of a Spherical Triangle, the reſt; as from two Sides and one Angle, the two other Angles and the third Side.

1. In all Right-angled Plane Triangles, if one of its Sides, be made the Radius, the other two will be the Sines, Tangents, or Secants, of the Acute Angles: And whatever Proportion the Side made has to the Radius, the ſame has the other Sides to the Sines, Tangents, or Secants, repreſented by this.

As



As if AC be the Radius, then

$$\left.\begin{array}{l} S.\ BAC : BC \\ S.\ ACB : AB \end{array}\right\}\left\{\begin{array}{l} :: \textit{Radius} : \textit{Hy-} \\ \textit{pothen.}\ AC. \end{array}\right.$$

If the Leg AB be the Radius, then

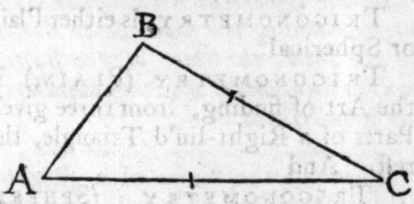
$$\left.\begin{array}{l} \textit{Radius} : AB \\ T.\ BAC : BC \end{array}\right\}\left\{\begin{array}{l} :: \textit{Sec.}\ BAC : \\ \textit{Hypothen.}\ AC. \end{array}\right.$$

If the Leg BC be made the Radius, then

$$\left.\begin{array}{l} \textit{Radius} : BC \\ T.\ ACB : AB \end{array}\right\}\left\{\begin{array}{l} :: \textit{Sec.}\ ACB : \\ \textit{Hypothen.}\ AC. \end{array}\right.$$

2. In any Right-lined Triangle the Sides are proportional to the Sines of the opposite Angles.

Whence in the Triangle ACB.



As,

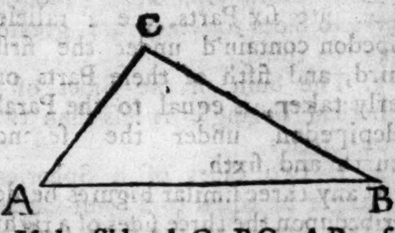
$$\left.\begin{array}{l} S.\ A \\ S.\ B \end{array}\right\} : S.\ C :: \left\{\begin{array}{l} BC \\ AC \end{array}\right\} : AB.$$

$$\left.\begin{array}{l} S.\ C \\ S.\ A \end{array}\right\} : S.\ B :: \left\{\begin{array}{l} AB \\ BC \end{array}\right\} : AC.$$

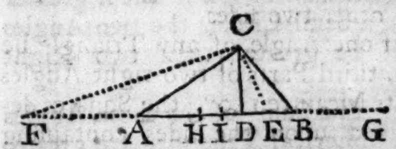
$$\left.\begin{array}{l} S.\ B \\ S.\ C \end{array}\right\} : S.\ A :: \left\{\begin{array}{l} AC \\ AB \end{array}\right\} : C.$$

In every Right-lined Triangle, as ABC, as the Sum of the Sides AB, AC, about a given Angle A is to their Difference, so is the Tangent of half the Sum of the remaining Angles B, C, to the Tangent of half their Difference.

TRI



If the Sides AC, BC, AB, of a Triangle ABC, be given, and if AB be bissected in I, and you take



upon it (when both Ways produced) the Lines AF, AE, equal to AC, and BG, BH, equal to BC, and join CE, CF, and from C let fall a Perpendicular CD, to AB, supposed the Base, then will the Area $= \frac{1}{4}\sqrt{FG \times FH \times HE \times EG}$. And for determining the Angle A, there come out several Theorems:

3. As $2\,AB \times AC : FH \times EG$ ($:: AC : DE$) $::$ Radius : versed Sine of the Angle A.

4. $2\,AB \times AC : \sqrt{FG \times FH}$ ($:: AC : DF$) $::$ Radius : versed Cosine of A.

5. $2\,\overline{AB \times AC} : \sqrt{FG \times FH \times HE \times EG}$ ($:: AC : CD$) $::$ Radius : Sine of A.

6. $\sqrt{FG \times FH} : \sqrt{HE \times EG}$ ($:: CF : CE$) $::$ Radius : Tangent of $\frac{1}{2}$ A.

7. $\sqrt{HE \times EG} : \sqrt{FG \times FH}$ ($:: CE : FC$) $::$ Radius : Cotangent of $\frac{1}{2}$ A.

8. $2\sqrt{AB \times AC} : \sqrt{HE \times EG}$ ($:: FE : EC$) $::$ Radius : Sine of $\frac{1}{2}$ A.

9. $2\sqrt{AB \times AC} : \sqrt{FG \times FH}$ ($:: FE : FC$) $::$ Radius : Cosine of $\frac{1}{2}$ A.

1. In every Spherical Triangle, each Side is less than a Semi-Circle.

2.

2. In every Spherical Triangle, any two Sides together are greater than the third.

3. The Sum of the Sides of a Spherical Triangle is leſs than two Semi-Circles.

4. If two Sides of a Spherical Triangle be equal to a Semi-Circle, the two Angles at the *Baſe* ſhall be equal to two Right Angles; if they be leſs than a Semi-Circle, the two Angles ſhall be leſs; but if greater than a Semi-Circle, the two Angles ſhall be greater than two Right Angles.

5. The Sum of the three Angles of a Spherical Triangle, are greater than two Right Angles, and leſs than ſix.

6. Two Angles of any Spherical Triangle are greater than the Difference between the third Angle and a Semi-Circle. Therefore,

7. Any Side being continued, the Exterior Angle is leſs than the two Interior oppoſite ones.

8. In any Spherical Triangle the Difference of the Sum of two Angles and a whole Circle, is greater than the Difference of the third Angle and a Semi-Circle.

9. In any Spherical Triangle, one Side being produced, if the other two Sides be equal to a Semi-Circle, the outward Angle ſhall be equal to the inward oppoſite Angle upon the Side produced: If they be leſs than a Semi-Circle, the outward Angle ſhall be greater than the inward oppoſite Angle; if they be greater than a Semi-Circle, the outward Angle ſhall be leſs than the inward oppoſite Angle.

10. The Legs of a Right-angled Spherical Triangle are of the ſame Affection with their oppoſite Angles.

11. In a Right-angled Spherical Triangle, if either Leg be a Quadrant, the Hypotheneuſe ſhall be alſo a Quadrant; but if both the Legs be of the ſame Affection (that is, be both greater, or both leſs than a Quadrant) the Hypotheneuſe is leſs than a Quadrant; or if of different Affections, then greater, and the contrary.

12. In a Right-angled Spherical Triangle, the Sum of the Oblique Angles are leſs than three Right Angles.

14. In any Spherical Triangle whoſe Angles are all Acute, each Side is leſs than a Quadrant.

15. In Spherical Triangles, there are twenty-eight Caſes, ſixteen in Rectangular, and twelve in Oblique Angular. The ſixteen Caſes of Rectangular are reſolv'd by the two firſt of the following Theorems.

THEO. I.

In all Spherical Rectangular Triangles, having the ſame Acute Angle at the Baſe, the Sines of the Hypotheneuſes are proportional to the Sines of their Perpendiculars.

THEO. II.

In all Spherical Rectangular Triangles, having the ſame Acute Angles at the Baſe, the Sines of the Baſes, and the Tangents of the Perpendiculars, are proportional.

That all the Caſes of a Right-angled Spherical Triangle may be reſolved by theſe two Theorems.

The ſeveral Parts of the Spherical Triangle propoſed, muſt ſometimes be continued to Quadrants, that ſo the Angles may be turn'd into Sides, the Hypotheneuſes into Baſes and Perpendiculars, and the contrary. By which Means the Proportions, as to the Parts of the Triangle given, inſtead of Sines, do ſometimes fall in Co-ſines, and ſometimes in Co-tangents, inſtead of Tangents. Such Parts as do change their Proportion, are noted with

with their Complements, *viz.* the Hypotheneuse, and both the Oblique Angles; but the Sides containing the Right Angle do not change.

These are called the Five Circular Parts of a Triangle, amongst which the Right Angle is not reckoned; and therefore the two Sides which do contain it, are supposed to be joined together.

Each of these Circular Parts, may, by Supposition, be made the Middle Part; and then the two Circular Parts, which are next to that Middle Part, are the Extreams conjunct; the other remote from the Part assumed, are the Extreams disjunct.

As in the Triangle ABC, (suppose a Triangle to be drawn,) if *Comp.* AC be made the Middle Part, *Comp.* A and *Comp.* C. are the Extreams conjunct; and the Side AB and BC are the Extreams disjunct; and so of the rest, as in the Table following.

Mid. Part.	*Extr. conj.*	*Extr. disj.*
Leg. AB	*Comp.* A *Leg.* BC	*Comp.* AC *Comp.* C
Comp. A.	*Comp.* AC *Leg.* AB	*Comp.* C *Leg.* BC
Comp. AC	*Comp.* A *Comp.* C.	*Leg.* AB *Leg.* BC
Comp. C.	*Comp.* AC *Leg.* BC	*Comp.* A *Leg.* AB
Leg. BC	*Comp.* C *Leg.* AB	*Comp.* A *Comp.* AC

The Parts of a Right-angled Spherical Triangle, being thus distinguished into five Circular Parts, for the more Ease in resolving all Spherical Triangles, the Lord *Napier* invented this Catholick and Universal Proportion, *viz.*

The Sine of the Middle Part and Radius is reciprocally proportional to the Tangents of the Extreams conjunct, and the Co-sines of the Extreams disjunct.

That is, as the Radius to the Tangent of one of the Extreams conjunct, so is the Tangent of the other Extream conjunct to the Sine of the Middle Part.

And also, as the Radius, to the Co-sine of one of the Extreams disjunct, so is the Co-sine of the other Extream disjunct, to the Sine of the Middle Part.

Therefore if the Middle Part be sought, the Radius must be in the first Place; if either of the Extreams, the other Extream must be in the first Place.

Only note, that if the Middle Part, or either of the Extreams conjunct, be noted with its Complement in the Circular Parts of the Triangle, instead of the Sine or Tangent, you must use the Co-sine or Co-tangent.

If either of the Extreams disjunct be noted by its Complement in the Circular Parts of the Triangle, instead of the Co-sine you must use the Sine of such Extream disjunct.

That the Directions may be better understood, there is in the Table following, the Circular Parts of a Triangle under their respective Titles, whether they be taken for the Middle Part, or for the Extreams; whether conjunct or disjunct; and unto those Parts there is prefixed the Sine and Co-sine, the Tangent or Co-tangent, as it ought to be by the Catholick Proportion.

Mid.

Mid. Part.	Extr. conj	Extr. disj.
Sine. AB	Co-tan. A Tan. BC	Sine AC Sine C
Co-sine A	Co-tan AC Tang. AB	Sine C Co-sine BC
Co-sine AC	Co-tan. A Co-tan. C.	Co-sine AB Co-sine BC
Co-sine C	Co-tan AC Tan. BC	Sine A Co-sine AB
Sine BC	Co-tan. C Tan. AB	Sine A Sine AC

THEO. III.

In all Spherical Triangles, the Sines of the Sides are in direct Proportion to the Sines of their Opposite Angles, and the contrary.

THEO. IV.

In all Oblique-angled Spherical Triangles, in which two Sides are less than a Semi-Circle:

As the Sine of half the Sum of the two Sides

To the Sine of half their Difference;

So is the Co-tangent of half the contained Angle,

To the Tangent of half the Difference of the Opposite Angles.

And, as the Co-sine of half the Sum of the Sides,

To the Co-sine of half their Difference;

So is the Co-tangent of half the contained Angle,

To the Tangent of half the Sum of the Opposite Angles.

THEO. V.

In all Oblique-angled Spherical Triangles, in which two Angles are less than two Right Angles:

As the Sine of half the Sum of two Angles,

To the Sine of half their Difference;

So is the Tangent of half the interjacent Side,

To the Tangent of half the Difference of the Opposite Sides.

And, as the Co-sine of half the Sum of the Angles,

To the Co-sine of half their Difference,

So is the Tangent of half the interjacent Side,

To the Tangent of half the Sum of the Opposite Sides.

THEO. VI.

As the Rectangle of the Sines of the containing Sides,

To the Square of the Radius;

So is the Rectangle of the Sines of half the Sum of the three Sides, and of the Difference of the Opposite Side therefrom,

To the Square of the Co-sine of half an Angle sought.

Ptolemy is the first Trigonometrical Writer. *Hipparchus* also wrote 12 Books concerning Triangles, but they are lost. Amongst the more modern, there are *Regio Montanus's Libri Quinque de Triangulis*, wrote *Anno* 1464, and published by *Schoner, Anno* 1533. You have *Pitiscus, Snell, Napier, Clavius, Ursinus, Gellebrand, John Newton, Seth Ward, Oughtred, Gooden* the Jesuit, *Norwood*, the *Wilsons* (two different Persons, one in *England*, and another in *Holland*,) *Ozanam, Dechales, Wolfius, Harris, Hains*, Dr. *Keil*, &c.

&c. who have all wrote of *Trigonometry.*

TRILATERAL, in Geometry, is the same with Three-sided.

TRINE, is an Aspect of the Planets, when at the Distance of 120 Degrees, or four Signs, from each other, and is noted thus △.

TRIANGLE, in Architecture, is a little Member fixed exactly upon every Triglyph under the Plat-Band of the Architrave, from whence hang down the *Guttæ*, or pendant Drops, in the *Dorick* Order.

TRINOMIAL ROOT, in Mathematicks, is a Root consisting of three Parts connected together by the Sign $+$; as $x+y+z$.

TRIPARTITION, is the Division by 3, or taking the third Part of any Number or Quantity.

TRIPLICATE RATIO, is the Ratio of the Cubes.

TRIS-DIAPASON, or *Triple Diapason Chord*, in Music, is what is otherwise called a *Triple Eighth*, or *Fifteenth*.

TRITONE, a Term in Music, which signifies a great Fourth.

TROCHILE, in Architecture, is that Hollow Ring, or Cavity, which runs round a Column next to the Tore.

TROCHLEA, is one of the Mechanic Powers, and is what we usually call the Pulley.

TROCHOID, the same with *Cycloid.* Which see.

TROPICAL YEAR. See *Year.*

TROPHY, in Architecture, is an Ornament which represents the Trunk of a Tree charged or encompassed all round about with Arms or Military Weapons, both offensive and defensive.

TROPICKS, are Circles supposed to be drawn parallel to the Equinoctial at 23° 30′ Distance from it; one towards the North, is called the *Tropick of Cancer*; and the other towards the South, is called the *Tropick of Capricorn*, because they lie under these Signs.

TRUCKS *of the Carriage of a Piece of Ordnance*, are the Wheels which are on the Axle-tree to move the Piece.

TRUE CONJUNCTION. See *Conjunction True.*

TRUE PLACE *of a Planet or Star*, is a Point of the Heavens shewn by a Right Line drawn from the Centre of the Earth, through the Centre of the Planet or Star.

TRUNCATED PYRAMID, or *Cone*, is one whose Top is cut off by a Plane parallel to its Base.

A *Truncated Cone*, or the Frustum of that Body, is called sometimes a *Curtie Cone.*

TRUNNIONS *of a Piece of Ordnance*, are those Nobs or Branches of the Gun's Metal which bear her up upon the Cheeks of the Carriages.

TURN, a Term belonging to the Movement of a Watch, and signifies the entire Revolution af any Wheel or Pinion.

TUSCAN ORDER, in Architecture, is the first, the most simple, and the strongest: Its Column has seven Diameters in Height; and its Capital, Base, and Entablement, have no Ornaments, and but few Mouldings.

TWILIGHT, is that faint Light which we perceive before the Sun-Rising, and after Sun-Setting. 'Tis occasioned by the Earth's Atmosphere refracting the Rays of the Sun, and reflecting them from the Particles thereof.

The Sun's Depression below the Horizon, at the Beginning and End of the Morning and Evening Twilight, was observed by *Alhazen* 19°. *Tycho* 17°. *Rothman* 24°. *Stevinus* 18°. *Cassini* 15°. *Ricciolus*, at the Time of the Equinox in the Morning 16°. in the Evening 20°. 30′. In the Summer Solstice in the Morning

21°.25′. and in the Winter 17°. 15′. Whence it appears that the Cause of the Twilight is inconstant: But about 18 Degrees of the Sun's Depression will, in our Latitude, be the Beginning and End of the Twilight.

Tympan, in Architecture, is that Part of the Bottom of the Frontons, which is enclosed between the Cornices, and answers the Naked of the Freze.

Tympan *of an Arch*, is a Triangular Table placed in its Corners.

V.

Vacuum, is by Philosophers supposed to be a Space devoid of all Body; and this they distinguish into a *Vacuum Disseminatum*, or *Interspersum*, *i. e.* small void Spaces interspersed about between the Particles of Bodies; or, a *Vacuum Coacervatum*, which is a larger void Space made by the meeting together of the several interspersed or disseminate Vacuities before mentioned.

Vane. Those Sights which are made to move and slide upon Cross-Staves, Fore-Staves, *Davis*'s Quadrants, *&c.*

Vapours, are Watry Exhalations raised up either by the Heat of the Sun, the subterraneal, or any other accidental Heat, Fire, *&c.*

Variation, is, according to *Tycho*, the third Inequality in the Motion of the Moon; and arises from her Apogæum being changed as her System is carried round the Sun by the Earth.

Variation *of the Needle*, or *Compass*, is the Deviation or Turning of the Magnetical Needle in the Mariner's Compass, from the true North Point, which happens more or less in most Places; and is commonly called by the Seamen the *North-Easting*, or *North-Westing* of the Needle.

Vectis, or the *Lever*, is the First of the Mechanic Powers, as they are usually called.

Vent, in Gunnery, signifies the Distance between the Diameter of a Bullet, and the Diameter of the Bore of the Piece, and must be one twentieth Part of the Diameter of the Bore.

Velocity. See *Celerity*.

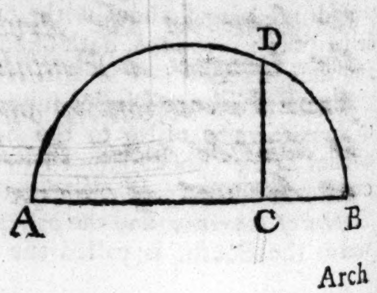
Venus, the Name of one of the Planets, being the second from the Sun.

The Distance of *Venus* from the Sun is 723, of such Parts, of which the Earth's are 1000, its Excentricity 5, the Inclination of its Orbit 3 Degrees, and 23 Minutes: It performs its Periodical Motion in 224 Days, 17 Hours; and its Motion round its Axis is performed in 23 Hours. The Diameter of it is almost equal to the Earth's Diameter.

In the Years 1672 and 1686, Mr. *Cassini*, with a Telescope of 34 Foot long, believes he saw a Satellite moving round this Planet, and distant from it about $\frac{2}{3}$ of *Venus*'s Diameter. It had the same Phasis with *Venus*, but was without any well defined Form, and its Diameter scarce exceeded $\frac{1}{4}$ of that of *Venus*.

Versed Sine *of an Arch*, is a Segment of the Diameter of a Circle, lying between the Foot of the Right Sine and the Lower Extremity of the Arch.

As A C is the Versed Sine of the



Arch

Arch A D, and C B the Versed Sine of the Arch B D.

Vertex, is that Point of the Heaven just over our Heads, and the same with the *Zenith*; which see.

The Point of any Angle is called also its Vertex, and that Point of the Curve of a Conick Section, where the Axis cuts it, is called also the Vertex of that Section.

Vertex, *of a Cone*, or *Pyramid*, &c. is the Point of the upper Extremity of the Axis, or the Top of the Figure: So the Vertex of an Angle, is the Angular Point.

Vertex *of a Glass*, in Opticks, is the same with its Poles; which see.

Vertical Circles: See *Azimuths*.

Vertical Line: See *Line Vertical*.

Vertical Opposite Angles: See *Angles*.

Vertical Plane, in Perspective: See *Plane*.

Vertical Point, the same with Vertex: So that in Astronomy, a Star is said to be Vertical, when it happens to be in that Point which is just over any Place.

Verticity, the Property of the Loadstone, or a touched Needle, to point North and South, or towards the Poles of the World; See *Magnet* and *Magnetism*.

Via Lactea: See *Milky Way*.

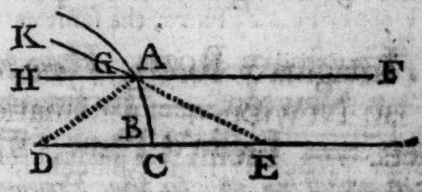
Vibration, is the Swing or Motion of a Perpendicular, or of a Weight hung by a String on a Pin.

Vindematrix, a fixed Star of the third Magnitude, in the Constellation *Virgo*, whose Longitude is 185 Degrees and 23 Minutes, Latitude 16 Degrees and 15 Minutes.

Virgo, one of the twelve Signs of the Zodiac, being the Sixth according to Order.

Virtual Focus, or *Point of Divergence in a Concave Glass* is the Point E in the following Figure.

Let the Concavity of the Glass be A B C, and its Axis D E: Let



F G be a Ray of Light falling on the Glass, parallel to the Axis D E; and let D be the Centre of the Arch A B C: This Ray F G, after it hath passed the Glass, at its Emersion at G will not proceed directly to H, but be refracted from the Perpendicular D G, and will become the Ray G K; draw directly G K, so as that it may cross the Axis in E, so found. Mr. *Molyneux* calls it the *Virtual Focus*, or *Point of Divergence*.

Visible Horizon: See *Horizon*.

Visible Place *of a Star*: See *Apparent Place*.

Vision, is a Sensation in the Brain, proceeding from a due and various Motion of the Optick Nerves, produced in the Bottom of the Eye, by the Rays of Light coming from any Object: by which means the Soul perceives the illuminated Thing, together with its Quantity, Quality, and Modification.

Visual Point, in Perspective, is a Point in the Horizontal Line, wherein all the Ocular Rays unite.

Visual Rays: See *Rays*.

Vitreous Humour, or *Glassy Humour of the Eye*, is the third Humour of the Eye, so called from its Resemblance of a melted Glass: It is thicker than the Aqueous, but not so solid as the Crystalline: It is round or convex behind, and somewhat plain before, only hollowed a

 little

little in the Middle, where it receives the Cryſtalline. It exceeds both the other Humours in Quantity.

Umbilicus, the ſame as *Focus*.

Umbilick Points, the ſame as *Foci*.

Unciæ, in Algebra, are thoſe Numbers which are prefixed before the Letters of the Members of any Power produced from a Binomial, Reſidual, or Multinomial Root.

Thus in the fourth Power of $a+b$, that is, $aaaa + 4\,aaab + 6\,aabb + 4\,abbb + bbbb$, the Unciæ are, 4, 6, 4.

Uniform Matter, is that which is all of the ſame Kind and Texture.

If there be a Right-angled Parallelepipedon of Uniform Matter, ſupported horizontally by two Fulcrums at its Ends, its Diſpoſition to break in any Part (or Point) of it by its own Gravity, will be as the Rectangle under the Diſtance of that Part (or Point) from each Fulcrum; and ſo its Diſpoſition to break in the Middle will be greateſt, ſince the Rectangle there becomes a Maximum.

This is true of *Cylinders* and *Priſms* likewiſe.

The ſame Thing being ſuppoſed when the Length and Breadth, and the Parallelepipedon remain the ſame, its Diſpoſition to break in the Middle (or at any other Point at the ſame Diſtance from the Fulcrums) will always be as the Square of the Height; and ſo the Strength of a Parallelepipedon, laid edge-ways upon the Fulcrums to its Strength when laid flat-ways, will be as the Height in one Caſe, is to the Height in the other.

From what has been ſaid, if the Upper Face of the Parallelepipedon, lying horizontally upon the two Fulcrums, be changed into a Curve Surface, being ſuch that all the Sections of the Solid, made by Planes perpendicular to the Horizon, and parallel to one of its Sides, be Semi-Elliptick Spaces of the ſame Magnitude, whoſe tranſverſe Axes are the Lengths of the Solid, and Semi-Conjugates the Height in the Middle: This Solid will have the ſame Diſpoſition to break in all its Parts; and ſo Joiſts, &c. cut after this Figure, will be as ſtrong as when they are of the ſame Height all the way as this Solid has in the Middle; and conſequently the Timber ſaved by cutting a Joiſt in Figure of this Solid, will be about three Parts out of fourteen.

If a ſolid Parallelepipedon of Uniform Matter be ſupported Horizontally, as a Prominent Beam in the Side of a Wall, the Diſpoſition to break of that Part coming out of the Wall in any Place by the Weight of the whole Prominent Part, will always be as the Diſtance of that Place from the End of the Prominent Part; and ſo its Diſpoſition to break at the Wall will be greateſt.

And if the Upper Surface of the Prominent Part be changed into a Curve Surface, ſuch that all Sections of it, by Planes parallel to the upright Faces of the Solid, and perpendicular to the Horizon, are equal Semi-Parabolas, having their Axes in the under Surface, and Vertexes in the lower Side of the End-Face of the Solid, which is parallel to the Wall, then this Prominent Solid will have the ſame Diſpoſition to break in any Part of it, that is, it will as ſoon break in one Part as the other; and ſo there may be $\frac{1}{3}$ Part of the Matter ſaved by cutting it into this Solid; and yet it will be as ſtrong as a Parallelepipedon, of the ſame Length, Breadth, and Height (that it has at the Wall) with itſelf, provided it be of the ſame Uniform Matter.

Uniform Motions, are the same with equal, or rather equable ones; which see.

Unison, is one and the same Sound.

Unit, or *Unity*, is the same as one, or 1.

Universal Equinoctial Dial, is one consisting of two Rings of Brass, or Silver, that open and fold together, with a Bridge or Axis, and a Slider, and a little Ring to hang or hold it up by: It is divided on one Side of the great Ring into 90 Degrees, and sometimes on the other into two Quadrants, or 180 Degrees, but one is enough. The innermost Ring is divided into 24 Hours, subdivided on the Face, and on the Outside of the Ring, into every 5 Minutes. The Axis has the Sun's Declination on one Side, and the Day of the Month, and the Sun's Place on the other.

To use it for the Hour, the Perpendicular Line, or Stroke, which is on the Slider, which moves on the outer Ring, must be set to the Latitude of the Place, and the Hole in the Slider, or the Bridge, either to the Sun's Place in the Ecliptick, the Day of the Month, or his Declination; and then the Rings being open'd, and set square to one another, move the Dial about, to and fro, till the Sun shines through the Hole, and on the inner Edge of the innermost Ring it will shew the true Hour.

The Hour of 12 cannot be shewn by this Dial, because the outermost Circle, or Ring, being then in the Plane of the Meridian, it hinders the Rays of the Sun from falling upon the innermost or Equinoctial Circle. And when the Sun is in the Equinoctial, you cannot tell the Hour of the Day by this Instrument, because at that Time his Rays fall parallel to the Plane of the said Equinoctial Circle: But this is but about one Hour every Day, and four Days in the Year.

Universal Problem, the same as *Indeterminate Problem*.

Volute, in Architecture, is one of the principal Ornaments of the *Ionic* and *Composite Capitals*, representing a kind of Bark wreathed or twisted into a Spiral Scroll. There are eight Angular Volutes in the *Corinthian Capital*, and these are accompanied with eight other little ones, called *Helices*.

Vortex, according to the *Cartesian* Philosophy, is a System of Particles of Matter moving round like a Whirl-Pool, and having no void Interstices, or Vacuities between the Particles.

One would have thought that this foolish Fable of *Vortexes* had been sufficiently exploded many Years ago, by the great *Newton*, *Cotes*, and other ingenious Persons, (see Mr. *Cotes*'s Preface to the 2d Edition of *Newton*'s *Principia*, as also the last Section of the Second Book of the said *Principia*;) but such is the Obstinacy, Partiality, and perhaps Folly of some of the *French*, that within this few Years they have again renewed the Controversy, and endeavoured to account for the Celestial Phænomena from this vain and imaginary Hypothesis. See the *Transactions of the* Royal *Academy* of Sciences at *Paris*, Anno 1715, 1728, 1729.

Upright South Dials. See *Prime Verticals*.

Ursa Major, a Northern Constellation, consisting of 27 Stars, and is otherwise called *Charles*'s *Wain*, and the *Great Bear*.

Vulgar Fractions. See *Fractions*.

W.

WADHOOK, among the Gunners, is a Rod or great Wire of Iron, turned in a Serpentine Manner; and its end is put upon a Handle or Staff, to draw out Wads, or Okum, that the Piece may be unloaded.

WAGONER. See *Charles's Wain*.

WARNING-WHEEL, in a Clock, is the third or fourth Wheel, according to its Distance from the first Wheel.

WATER, is a very fluid volatile and tasteless Substance, very probably consisting of Hard, Smooth, Ponderous, Spherical Particles, of equal Diameters, and of equal Specifical Gravities.

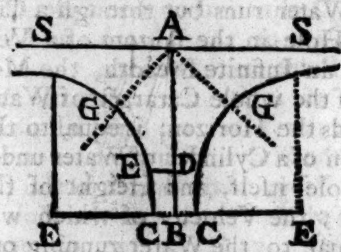
The Porosity of Water is so very great, that there is at least forty Times as much Space as Matter in it; for Water is nineteen Times specifically lighter than Gold, and so rarer in the same Proportion; but Water can be pressed through the Pores of Gold, and therefore may be supposed, at least, to have more Pores than Solid Matter.

Mr. *Boerhaave*, in his Chemistry, defines Water to be a Liquor very fluid, inodorous, insipid, pellucid, and colourless, which in a certain Degree of Cold freezes into a brittle, hard, glassy Ice.

Well Water, which is esteemed the most pure of all, is in Weight, to pure Gold, as 1 to $19\frac{151}{233}$. An *English* Cubick Inch, Mr. *Boyle* says, weighed 252, 256, 260 Grains. Heat easily makes Waters lighter, and the heavier they are, the more they are to be suspected of having hetereogenous Matter within them. — *Boerhaave* says, *Clavius* the Mathematician, poured some Water into a Bolt-head, and then sealed the Mouth of its long Neck hermetically, and marked with a Diamond the Height to which the Water arose at that time: He then hung it up, and 80 Years after it was found in *Kircher*'s Study, just as full as it was at first. So that from hence it would seem, that Water will not pass thro' Glass.

The Motion of Water running out of a Hole in a Vessel may be thus defined.

Let S A S be an infinite Superficies of Water, C C a Circular Hole made in the Bottom of a Vessel, A B a strait Line drawn perpendicular through the Hole. S G C C a Column or Cataract of Water running out through the Hole C C, S G C a Curve, by the Rotation of which, about the Axis A B, the Solid or Cataract S G C C S is gene-



rated; for since the Water descends freely, and with an accelerate Motion, it must of necessity be contracted into a less Breadth, according as in falling it requires a greater Velocity, and will run out through the Hole C C with the same Velocity that it would have in falling the Height A B.

Now the Velocity that a heavy Body acquires by falling, is in the subduplicate Ratio of the Height from whence it falls: Wherefore if any Ordinate D E be drawn to the Curve S G C, and D E be called y, and A D, x; then the Velocity of the Water, in the Section E D, will be expressed by $\sqrt{x}$, and the Product of that Velocity drawn into the said Section by $\sqrt{x}\,x\,y^2$.

Which

Which Product is as the Quantity of Water passing through that Section in a given Space of Time, and because the same Quantity of Water passes through each Section of the Cataract in a given Time, that Product will be always equal to itself; and so $\sqrt{x} \times y^2 = 1$, and $x \times y^4 = 1$ which is an Equation of the Curve S G C, being an Hyperbola of the 5th Order, one of the Assymptotes being the Right Line A S parallel to the Horizon, and the other the Line A B perpendicular to it:

The Power of it is the Quadrato-Cube of the Ordinate E D drawn to the Point G, where the Right Line AG bissecting the Angle, formed by the Assymptotes, meets the Curve.

If Water runs out through a Circular Hole in the Bottom of a Vessel of an Infinite Breadth, the Motion of the whole Cataract of Water towards the Horizon, is equal to the Motion of a Cylinder of Water under the Hole itself, and Height of the Water; the Velocity of which will be equal to the Water running out through the Hole, or equal to the Motion of a Quantity of Water, which runs out in a given time, the Velocity of which will be equal to that which is acquired in that same given Time by the Motion, through a Space, equal to the Height of the Water.

If $BA : BD :: DG^4 : DG^4 - BC^4$. and Water runs out through C C, a Circular Hole made in the Middle of the Bottom of a Cylindrical Vessel G G E E constantly full of Water, the Motion of a Cataract of Water towards the Horizon, shall be equal the Motion of a Cylinder of Water under the Hole, and the Height A B, whose Velocity shall be equal to the Velocity of the Water running out through the Hole; or it shall be equal to the Quantity of Water which runs out in a given Time, with such a Velocity as is acquired in that same given Time to move through a Space equal to the Height A B; and if the Vessel and the Hole be of any other Figure, the Motion of the Cataract of Water will be the same, using a Proportion of Water of the Height A B for a Cylinder.

WAY *of the Rounds*, in Fortification is a Space left for the Passage of the Rounds between the Rampart and the Wall of a fortified Town: But it is not so much in use, because not having a Parapet above a Foot thick, it may be soon overthrown by the Enemies Cannon.

WEDGE, is a Prism of a small Height, whose Bases are Æquicrural Triangles, as A.

The Height of the Triangle is the Height of the Wedge, as *d b*.

The Base of the Triangle is called the Base of the Wedge, as *e e*.

The Edge of the Wedge is a Right Line, which joins the Vertices of the Triangles, as *b f*.

The Edge of the Wedge is applied for cleaving of Wood, and the Power is the Blow of a Hammer, or Mallet, which drives the Wedge into the Wood.

The Power is to the Resistance of the Wood, when its Action is equal to it, as the Half-Base of the Wedge is to its Height.

Wind, is any ſenſible Agitation of the Air, and is cauſed by the Action of the Sun's Beams upon the Air and Water, as he paſſes every day over the Ocean, conſidered together with the Nature of the Soil and Situation of the adjoining Continents.

It is found by Experience that the Velocity of the Wind in a great Storm is not more than 50 or 60 Miles in an Hour, and that a common briſk Wind moves about 15 Miles an Hour: And the Courſe of many Winds is ſo ſlow, as to be leſs than one Mile in an Hour.

Concerning the Cauſe of the Winds, and the manner of accounting for the ſeveral Phænomena thereof, in the different Parts of the World, ſee Dr. *Halley*'s Diſcourſe upon this Subject, *Philoſ. Tranſ.* N° 183. as alſo *Varenius's General Geography* (Part abſol.) Sect. 6 Cap. 20. The Lord *Bacon* too has wrote a little Treatiſe upon the Winds.

Wings, in Fortification, are the large Sides of Horn-Works, Crown-Works, Tenails, and the like Out-Works; that is to ſay, the Ramparts and Parapets, with which they are bounded on the Right and Left, from their Gorge to their Front. Theſe Wings or Sides are capable of being flanked either with the Body of the Place, if they ſtand not too far diſtant, or with certain Redoubts, or with a Traverſe, made in their Ditch.

Winter Solstice. See *Solſtice.*

Y

Year, is the Time the Sun takes to go through the twelve Signs of the Zodiack. This is properly the Natural or Tropical Year, and contains 365 Days, 5 Hours, and 12 Minutes.

The Sydereal Year is that Time in which the Sun, departing from any fixed Star, comes to it again; and this is in 365 Days, 6 Hours, and almoſt 10 Minutes: But according to Sir *Iſaac Newton*'s *Theory of the Moon*, the Sydereal Year is 365 Days, 6 Hours, 9 Minutes, 14 Seconds; and the Tropical, 365 Days, 5 Hours, 48 Minutes, 57 Seconds.

Z

Zenith. If we conceive a Line drawn through the Obſerver and the Center of the Earth, which muſt neceſſarily be perpendicular to the Horizon, it will reach to a Point among the fixed Stars, which is called the *Zenith.*

Zenith Distance, is the Complement of the Sun, or Star's Meridian Altitude, or what the Meridian Altitude wants of 90 Degrees.

Zetetick Method, in Mathematicks, is the Analytick or Algebraick Way, whereby the Nature and Reaſon of the Thing is primarily inveſtigated and diſcovered.

Zocco. See *Plinthus.*

Zocle, in Architecture, is a ſquare Body, leſs in Height than Breadth, and placed under the Baſes of the Pedeſtals of Statues, Vaſes, *&c.*

Zodiack, is a Zone or Belt which is imagined in the Heavens, which the Ecliptick Line divides into two equal Parts; and which, on either Side, is terminated by a Circle parallel to the Ecliptick Line, and eight Degrees diſtant from it, on account of the ſmall Inclinations of the Orbits of the

Planets,

Planets, to the Plane of the Ecliptick: No Bodies of the Planetary System appear without the Zodiack.

ZODIACK *of the Comets*, is a certain Tract in the Heavens, within whose Bounds most Comets are observed to keep their Course.

ZONE, in Geography, is a Space contained between two Parallels.

The Whole Surface of the Earth is divided into five Zones. The First is contain'd between the two Tropicks, and is called the *Torrid Zone*. There are two Temperate Zones, and two Frigid Zones. The Northern Temperate Zone is terminated by the Tropick of *Cancer*; and the Arctick Polar Circle, the Southern Temperate Zone is contained between the Tropick of *Capricorn*, and the Polar Circle: The Frigid Zones are circumscribed by the Polar Circles; and the Poles are in the Centres of them.

In the Torrid Zone, twice a Year the Sun goes through the Zenith at Noon; for the Elevation of the Pole is less than 23 Degrees, 30 Minutes; and the Distance of the Sun from the Equator towards the Pole, which is above the Horizon, is twice in a Year equal to the Height of the Pole; for which Reason also, in the Limits of that Zone, namely under the Tropicks, the Sun comes to the Zenith only once in a whole Year.

In the Temperate and Frigid Zones, the least Height of the Pole exceeds the greatest Distance of the Sun from the Equator, and therefore, to their Inhabitants, the Sun never goes through the Zenith; yet if on the same Day the Sun rises at the same Time to a greater Height, the less the Height of the Pole is, because thereby the Inclination of the Circles of the Diurnal Revolution with the Horizon is less.

In the Torrid Zone, and in the Temperate Zones, every Natural Day the Sun rises and sets; for the Distance of the Sun from the Pole always exceeds the Height of the Pole; yet every where, but under the Equator, the Artificial Days are unequal to one another, which inequality is so much the greater, the less the Place is distant from a Frigid Zone.

But in the Polar Circles, just where the Temperate Zones are separated from the Frigid ones, the Height of the Pole is equal to the Distance of the Sun from the Pole, when it is in the Neighbouring Tropick; and therefore, in that Case, once a Year, the Sun in its Diurnal Motion performs one entire Revolution, without going down under the Horizon.

But every where in a Frozen Zone, the Height of the Pole is greater than the least Distance of the Sun from the Pole; therefore, during some Revolutions of the Earth, the Sun is at a Distance from the Pole, which is less than the Pole's Height; and, during all that Time, it does not set, nor so much as touch the Horizon; but where the Distance from the Pole, as the Sun recedes from it, does exceed the Height of the Pole or Latitude of the Place, the Sun rises or sets every Natural Day. Then in its Motion towards the opposite Pole, it stays in the same Manner below the Horizon, as was said of the Motion above the Horizon.

These Times in which the Sun makes entire Revolutions above the Horizon, and below it in its Diurnal Motion, are so much the greater, that is, the longest Day and Night last the longest, the less the Place in the Frigid Zone is distant from the Pole, till, at last, at the Pole itself, they take up the Time of the whole Year.

FINIS.

To be added to the Head of ROOTS OF EQUATIONS.

THERE have been many Endeavours to find the Roots of Equations in finite Terms by Authors. Sir *Isaac Newton* himself has given a tentative Method of finding whether an Equation of four, six, or more Dimensions may be divided so into two equal Parts, as that the Root of each may be extracted. But his Rule for so doing it, is very long and troublesome, serving more, as he himself owns, to shew the possibility of doing the thing than for any real use. See his *Algebra* towards the End. You have also in the *Acta Eruditorum, an.* 1683. *p.* 204. an universal Way of Mr. *Tschirnhausen's*, of finding the Roots of Equations, by throwing out all the intermediate Terms. But this is both tedious and false, when the Equation has more than three Dimensions. The Ingenious Mr. *De Moivre,* likewise in the *Philosophical Transactions,* N°. 309, has a given way of resolving in finite Terms, particular Equations of the odd Dimensions *ad Infinitum* contained in this general Equation, when n is an odd Number,

$$n x + \frac{nn-1}{2\times3} n x^3 + \frac{nn-1}{2\times3} \times \frac{nn-9}{4\times5} n x^5 + \frac{nn-1}{4\times5} \times \frac{nn-9}{4\times5} \times \frac{nn-25}{6\times7} n x^7 \text{ \&c.} = a.$$

Being a Series for dividing an Arch of a Circle into any odd Number of equal Parts. But to speak Truth, whatever Arithmetical Rules have hitherto, or ever will be given for finding the Roots of Equation of more than three Dimensions in finite Terms, must from the Nature of the Thing be not worth the Pains and Perplexity in computing them by reason of their unelegance and length; for ever encreasing with the Number of Dimensions of the Equation, whose Roots are to be sought. I shall only mention a way of Sir *Isaac Newton*'s of finding the Roots of Numerical Equations by means of *Gunter*'s Lines sliding by one another.

Take as many *Gunter*'s Lines, (upon narrow Rules) all of the same Length, sliding in Dove-tail Cavities, made in a broad oblong Piece of Wood, or Metal, as the Equation whose Roots you want the Dimensions of, having a Slider carrying a Thread or Hair backward or forwards at right Angles over all these Lines, and let these *Gunter*'s consist of two single ones, and a double, triple, quadruple, *&c.* one fitted to them; that is, let there be a fixed single one a top, and the first sliding one next that, let be a single one, equal to it, each Number from 1 to 10. Let the second sliding one be a double Line of Numbers, number'd 1, 2, 3, 4, 5, 6, 7, 8, 9, to 10, in the Middle, and from 1 in the Middle, to 1, 2, 3, *&c.* to 10, at the End. Let the third sliding one be a triple Line of Numbers, numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 1, and again 2, 3, 4, *&c.* to 10, and again 2, 3, 4, *&c.* to 100 at the End. The Distance from 1 to 1, 1 to 10, and 10 to 100, being the same; let the fourth sliding one, be numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 1; and again 2, 3, 4, *&c.* to 10; and again 2, 3, 4, *&c.* 100; and again 2, 3, 4, *&c.* 1000. The Distance from 1 to 1, 1 to 10, 10 to 100, and 100 to 1000, being the same, and so on.

This being done, take the Coefficient prefixed to the single Value of the unknown Quantity upon the fixed single Line of Numbers; the

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Co-efficient of the Square of the unknown Quantity, upon the double Line of Numbers; the Co-efficient of the Cube of the unknown Quantity, upon the triple Line of Numbers; the Co-efficient of the Biquadrate of the unknown Quantity, upon the Quadruple Line of Numbers; and so on. And the Co-efficient of the first or highest Term (being always Unity) take upon that Line of Numbers expressed by its Dimension, that is, if a Square, upon the double Line; a Cube, upon the triple Line, *&c.* I say, when this is done, slide all these Lines of Numbers so, that these Co-efficients be all in a right Line directly over one another, and keeping the Rulers in this Situation, slide the Thread or Hair in such manner, that the Sum of all the Numbers upon the fixed single Line, the double Line, the triple Line, *&c.* which the Thread or Hair cuts, be equal to the known Term of the Equation, which may be readily enough done with a little practice; and then the Number under the Thread upon that Line of Numbers of the same name with the highest Power of the unknown Quantity of the Equation, will be the pure Power of the unknown Quantity, whose Root may be had by bringing Unity on the single Sliding-Line directly over Unity upon this Line. After this, if you divide the Equation by this Root, you will have another, one Dimension less; and thus you may proceed to find a Root of this last Equation· which done, if it be divided by this last Root, you will get an Equation two Dimensions less, and by a Repetition of the Operation you will get a third Root, and so a fourth, fifth, *&c.* if the given Equation has so many, and if any of the intermediate Terms are wanting, the *Gunter*'s express'd by the Dimensions of those Terms, must be omitted.

But this Method only gives the Roots of Equations the Signs of all the Terms whereof, except the known one, are Affirmative; that is, of such that have all Negative Roots, but one, which last, the said Method finds. Therefore when an Equation is given, to find its Roots after this manner, whose Signs have other Dispositions, it must be first changed into another Equation, whose Signs are all Affirmative; but that of the known Term, which may be done by putting some unknown Quantity y Plus or Minus, some given Number or Fraction, for the Value of the unknown Quantity x in the proposed Equation.

Note, Instead of streight Parallel Sliding-Rules, you may have so many *Gunter*'s Lines graduated upon Concentrick Circles, each moving under one another, by which Contrivance, you will have as large Divisions for your Logarithm within the Compass of one Foot, as you have upon a streight Ruler of more than three Feet in Length. Although perhaps by these Sliding-Rules, you cannot get all the Signs of the Roots exactly, for want of sufficient Subdivisions of the *Gunter*'s Lines, yet if we can get two or three of the first Figures, it will be of good use to find the Roots by Approximation.

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ABacus, in the Figure for *e*, read *c*. Acceſſible Altitude, in the Figure for 663, read 66.3. Acceſſible Depth, for $16\frac{1}{2}$ *Feet*, r. 16 *Feet* and 1 *Inch*. Addition of Decimal Fractions, for the Sum of 36.24, *&c.* r. 907.023. Algebra Specious, line 2, for *formed* r. *performed*. Alternation, line 10, for *Alteration* r. *Alternation*. Altitude Inacceſſible, l. 28. for BAC r. BCA. Line 103, for *take it from*, r. *take from it*. Line 115, for HI, r. HC. Altitude of a Figure, l. 3. for *of* r. *to*. Altitude Meridian, l. 25, for 20 r. 200. Angles Curved Lin'd, l. 30, for DCE, r. DCA. Angles Equal, l. 10. for DF r. DE. Angle of Emergence, the Letter E wanted in the Figure where the Line AB interſects the Parabola. *Ibidem*, l. 15, for CD r. CB. *Angle Rightline*, r. *Angle Right-lin'd*. Angle in a Segment, for ACB r. ADC. *Ibid. Fig.* 2. for D r. B. Angle Spherical, l. 5. dele *the Angle re-entring*. Line 5. for *thoſe* r. *whoſe*. Anomaly Coequate, or True, l. 50. for *Keil*, r. *Keil*'s. Apparent Magnitude, n. 1. l. 9. add *afterwards*. *Ibid.* n. 2. l. 1. for CH, r. CD. And l. 3. r. CAD. N. 9. l. 8. after AC add *and* AB—BC. *Ibid.* n. 13. for MH, r. QH. Antiparallels, l. 6. add *that cut them the ſame way*. Antipodes, l. 26. r. *St. Auguſtine* in. Apotome, the Letter G is miſplaced. Aſtronomy, l. 20. for *forty-ſeven*, r. *four hundred and ſeventy*. Axis Conjugate, for EF, r. FF. Baſe the leaſt Sort of Ordnance, for $1\frac{1}{4}$, r. $1\frac{1}{8}$. Binomial Root l. 21. for *next*, r. *reſt*. *Ibidem*, l. 24. r. *Dimenſion*. *Ibid.* l. 32. for $\frac{bbx}{a}$ r. $\frac{bxx}{a}$. *Ibid.* l. 50. for $\frac{c^4x+c^5}{-x^5}$, r. $\frac{c^4x-x^5}{-c^5}$. *Ibid.* l. 57. for $\frac{N}{\sqrt{y^3-a^2y}}$, r. $\frac{N}{\sqrt[3]{y^3-a^2y}}$; and for $N\times\overline{y^3-a^2y}|^{-\frac{1}{2}}$, r. $N\times\overline{y^3-a^2y}|^{-\frac{1}{3}}$. *Ibid.* l. 62. for BC, r. B. *Ibid.* l. 65. for *Point*, r. *Power*. *Ibid.* l. 71. for *fourth*, r. *fifth*. *Ibid.* l. 121. for *ventured*, r. *entered*. Under this Word in Sir *Iſaac Newton*'s Example of extracting the Root, for $1-xc$, r. $1-xx$. Biquadratic Equation, n. 2. l. 55. for *sxx*, r. *xx*. *Ibid.* n 2. l. 7. under the word Conſtruction, for C, r. *c*. *Ibid.* n. 7. l. 49. for $\overline{AF}^2 = -\overline{AG}^2$ r. $\overline{AF}^2 - \overline{AG}^2$. Biquadratic Parabola, l. 15. dele *or* AC. *Ibid.* l. 147. for *where*, r. *when*. Biſſextile, l. 9. for *24th*, r. *28th*. Bombe, Paragr. 9. at the End, add *according to the parabolic Hypotheſis*. *Ibid.* l. 30. for *Impreſſes*, r. *Impulſes*. N. 4. l. 16. dele *plane*. Calculus Differentialis, parag. 5. l. 43, for $\frac{1}{2}$ ABC, r. $\frac{1}{2}axx$. Centre Common of Gravity, in the parag. next n. 13. l. 30. for $\frac{1}{2}$ AB, r. AB. *Ibid.* l. 34. for $\frac{1}{2}$ *the Radius*, r. *the Radius*. *Ibid.* in the Fig. n. 6. inſtead of the Letter P at the End of the Line EP, ſhould be F. Circle, n. 19. E is the Centre. *Ibid.* n. 25. l. 3. for *Theorems*, r. *Propoſitions*. *Ibid.* n. 30, l. 30, after 14. put a Comma. *Ibid.* Prob. 5. for D at the bottom of *Fig.* 1. read G. The Letter M near the bottom of *Fig.* 2. is wanted. And for F near the bottom of *Fig.* 3. r. P. Alſo l. 21. for ME, r. MP. Conchoid, the Letter A is wanted in *Fig.* 4. Cone, n. 4. l. 16. for *Plane Curve Superficies*, r. *Plane Superficies terminated by a Curve*. Croſs-

Multiplication,

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Multiplication, l. 13. for *Inches*, r. *Feet*. Curves in Geometry, parag. 4. l. 3. for *Diameters*, r. *Dimensions*. Cycloid, parag. 7. l. 43. for *Farnat*, r. *Fermat*. Decimal Fractions, l. 10. for $\frac{346}{10000}$ r. $\frac{346}{1000}$. Fluent, paragr. 4. l. 20. for fzn. r. fz^n. *Ibid*. l. 22. for *Terms*, r. *Forms*. *Ibid*. parag. 7. l. 7. for $a\dot{x}xm$. r. $a\dot{x}x^m$. Fluxions second, parag. 2. l. 4, 5. for *Quantities* $\overline{x+x}|^{\frac{m}{n}}$, r. *Quantity* $\overline{x+\dot{x}}|^{\frac{m}{n}}$. Heptagon, l. 2. for *several*, r. *seven*. Hyperbola, n. 2. parag. 2. l. 6. for D, r. G. *Ibid*. l. 12. for *Points*, r. *Pins*. *Ibid*. n. 5. l. 8. for RQ r. AR. *Ibid*. n. 6. the Letter T is wanted in the Figure. Hyperbolic Cylindroid, l. 4. for *there*, r. *they*. Hyperbolic Space, the Letter F misplaced, it should be where the Line drawn from L cuts the Curve. *Ibid*. l. 5. for CF, r. LF. *Ibid*. l. 6. for a^2, r. ab. Imaginary Root, parag. 5. l. 13. for *Square*, r. *Squares*. *Ibid*. parag. 6. l. 8. dele *an Ordinate*. Impervious, l. 5. for *do*, r. *to*. Indetermined Problem, n. 4. parag. 5. l. 31. for $\frac{21 \times 17 \times 11}{4} = 94$. r. $\frac{21 \times 17 + 11}{4} = 92$. *Ibid*. l. 36. for 94, r. 92. Index, l. penult. for $\frac{1}{\sqrt{x^5}}$, r. $\frac{1}{\sqrt[3]{x^5}}$. Interest, l. 2. for *Lot*, r. *Loan*. Mathematics, parag. 9. l. 20. for *assaults*, r. *assaults with*. Mercator's Chart, n. 4. l. 10. for AB, r. A*b*. Oscillation, n. 4. for *three Feet*, 3.125. r. 3.125 *Feet*. Parabola, n. 4. for *the Right Line* FM, r. *the Square of the Right Line* FM. *Ibid*. l. 4. for *the Abscissæ*, r. *the Squares of the Absciss*. Parabola Cartesian, l. 8. for DN, r. BN. Perfect Number, l. 23. for y, x. r. y^2x. Quadratic Equation, n. 3. for $-\frac{1}{2} - \sqrt{\frac{1}{4}aa - b}$. r. $\frac{1}{2}a - \sqrt{\frac{1}{4}aa - b}$. *Ibid*. n. 11. for $\sqrt{\frac{1}{4}aa + b}$, r. $\sqrt{\frac{1}{4}aa - b}$. Ratio, n. 7. l. 38. for *on*, r. *to*.

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